PURIFIED POLYMERIC MATERIALS AND METHODS OF PURIFYING POLYMERIC MATERIALS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part application of U.S. Patent Application No. 10/648604, Attorney Docket Nos. 126750-1; filed August 26, 2003, which is herein incorporated by reference in its entirety.

BACKGROUND OF INVENTION

The present methods are directed to purifying polymeric material by filtering melts comprising poly(arylene ether) and/or poly(alkenyl aromatic) resins. The methods are more particularly directed to filtering melts comprising poly(arylene ether) and/or poly(alkenyl aromatic) resins to result in filtered polymeric materials having reduced amounts of particulate impurities.

Optical, magnetic and magneto-optic media are primary sources of high performance storage technology that enable high storage capacity coupled with a reasonable price per megabyte of storage. Areal density, typically expressed as billions of bits per square inch of disk surface area (gigabits per square inch ($Gbits/in^2$)), is equivalent to the linear density (bits of information per inch of track) multiplied by the track density in tracks per inch. Improved areal density has been one of the key factors in the price reduction per megabyte, and further increases in areal density continue to be demanded by the industry.

In the area of optical storage, advances focus on access time, system volume, and competitive costing. Increasing areal density is being addressed by focusing on the diffraction limits of optics (using near-field optics), investigating three dimensional storage, investigating potential holographic recording methods and other techniques.

Polymeric data storage media has been employed in areas such as compact disks (CD) and recordable or re-writable compact discs (e.g., CD-RW), and similar relatively low areal density devices, e.g. less than about 1 $Gbits/in^2$, which are typically read-through

devices requiring the employment of a good optical quality substrate having low birefringence.

Unlike the CD, storage media having high areal density capabilities, typically up to or greater than about 5 Gbits/in^2, employ first surface or near field read/write techniques in order to increase the areal density. For such storage media, although the optical quality of the substrate is not relevant, the physical and mechanical properties of the substrate become increasingly important. For high areal density applications, including first surface applications, the surface quality of the storage media can affect the accuracy of the reading device, the ability to store data, and replication qualities of the substrate.

While there are materials presently available for use in data storage media, there remains a need for additional polymeric materials possessing the combined attributes necessary to satisfy the increasingly exacting requirements for data storage media applications.

SUMMARY OF INVENTION

In one embodiment, the above-described needs are alleviated by a method of purifying a polymeric material comprising melt blending poly(arylene ether) and poly(alkenyl aromatic) in an extruder to form a melt (also called a melt mixture); and filtering the melt through a melt filtration system to produce a filtered polymeric material.

In another embodiment, the melt filtration system utilizes a screen pack, a sintered metal filter, or a combination thereof. In another embodiment; the melt has an average residence time in the extruder of less than or equal to about 5 minutes.

In another embodiment, a composition comprising poly(arylene ether) and poly(alkenyl aromatic) is provided wherein the composition has less than 30, preferably less than 20, more preferably less than 10, particulates having an average diameter of 30 micrometers per gram of the composition.

In another embodiment, a composition comprising poly(arylene ether) and poly(alkenyl aromatic) is provided wherein the composition has less than 200, preferably less than 140, more preferably less than 100, particulates having an average diameter of 20 micrometers per gram of the composition.

In another embodiment, a filtered polymeric composition is provided that has less than 30, preferably less than 20, more preferably less than 10, particulates of 30 micrometer average diameter per gram of the filtered composition in combination with less than 200, preferably less than 140, more preferably less than 100, particulates having an average diameter of 20 micrometer per gram of the filtered composition.

In another embodiment, filtered compositions, including the aforementioned filtered compositions, are provided wherein the compositions contain zero particulates having an average diameter of 175 micrometers or larger, preferably 140 micrometers or larger, and more preferably 100 micrometers or larger, per gram of the filtered composition. Other embodiments, including articles made from the filtered polymeric material, are described below.

DETAILED DESCRIPTION

Due to the surface quality requirements of high areal density storage media, it is desirable that current data storage media are prepared from materials containing limited quantities of particulate impurities. Visible particulate impurities, such as gels and carbonized polymeric material, are undesirable as an aesthetic defect resulting in a consumer's perception of an inferior quality product. Particles having sizes larger than about 50 micrometers can act as stress concentrators in molded articles, thereby reducing the impact strength of these articles. Particulate impurities about 1 micrometer in size contribute to an increase in haze which can affect the transmittance of light through or transparency of articles molded from material containing such impurities. Most importantly, particulate impurities may affect surface quality of storage media thereby affecting read accuracy, data storage, and replication.

Visible particulates or "black specks" are dark or colored particulates generally visible to the human eye without magnification and having an average diameter of 30 micrometers or greater. Although some people are able to without magnification visually detect particles having an average diameter smaller than 30 micrometers and other people can detect only particles having an average diameter larger than 30 micrometers, the terms "visible particles," "visible particulates," and "black specks" when used herein without reference to a specified average diameter means those particulates having an average diameter of 30 micrometers or greater. Black specks, as well as other smaller microscopic particulates, are typically present in poly(arylene ether) compositions as the poly(arylene ether) is subject to oxidative degradation at high temperatures. Poly(arylene ether)s tend to form carbonized "black specks" when processed at the high extruder shear rates and/or at high temperatures for extended periods of time as are typically used in the manufacture of compositions of poly(arylene ether) and poly(alkenyl aromatic) resins.

The above-described needs are alleviated by a method of purifying a polymeric material comprising melt blending poly(arylene ether) and poly(alkenyl aromatic) in an extruder to form a melt; and filtering the melt through a melt filtration system to produce a filtered polymeric material. The melt generally has an average residence time in the extruder of less than or equal to about 5 minutes. The filtration removes particulate impurities present in the polymeric material to result in a filtered polymeric material comprising reduced quantities of particulate impurities.

As used herein the term "polymeric material" is inclusive of a composition comprising poly(arylene ether) resin and poly(alkenyl aromatic) resin.

As described herein, melts of polymer mixtures, such as poly(arylene ether) and poly(alkenyl aromatic) mixtures, may be melt filtered to remove particulate impurities. The residence time, temperature, and shear rate of the melt in the extruder should be controlled to minimize decomposition of the polymeric material, especially the poly(arylene ether) component. Poly(arylene ether)s are known to oxidize and form gels if maintained at high temperatures. These resins may also form carbonized "black specks" or degrade in color (darken) if processed at high temperatures for

extended periods of time. Therefore, it is preferable to minimize the residence time of the melt by selection of extruder length and extruder screw design and by controlling the screw speed and feed rate. An average residence time of less than or equal to about 5 minutes may be employed, with less than or equal to about 2 minutes preferred, and less than or equal to about 1 minute more preferred.

It is also preferable to minimize the residence time of the melt through the melt filtration system. The melt filtration system may be designed to provide short residence times based on, among other options, the selection of the surface area of the filter, the type of filter, and volume of the melt filtration housing. A higher filter surface area and a smaller housing volume can provide shorter residence times.

The melt filtration system of the extruder is preferably located at the terminal barrel of the extruder, and more preferably at the die head of the extruder. The extruder may comprise a single melt filtration system or multiple melt filtration systems, including combinations of different types of melt filtration systems.

Any type of extruder that is capable of providing a homogenous melt of poly(arylene ether), poly(alkenyl aromatic) and/or additional resins and additives, may be used. Useful types of extruders include, for example, a twin screw counter-rotating extruder, a twin screw co-rotating extruder, a single screw extruder, a single screw reciprocating extruder, a kneader, a ring extruder, a combination of the foregoing, and the like. Preferably a single extruder may be used, but multiple extruders may be employed.

Although single screw extruders may be utilized, it is generally preferable to use multi-screw extruders due to their greater pumping capability through the melt filtration system. Twin-screw counter-rotating extruders, such as those manufactured by Leistritz Extrusionstechnik and NFM Welding-Engineers, are useful and are often preferred where higher pressures or longer residence times are desired. Conical counter-rotating twin-screw extruders, such as those manufactured by Milacron, are also preferred due to large feed capabilities and high pumping efficiencies. Twin-screw co-rotating, intermeshing extruders, such as those manufactured by Coperion

Werner-Pfleiderer, are especially preferred due to their high through-put rates, short residence times, flexible screw designs, outstanding alloying, and other design benefits. Both three-lobe and two-lobe machines are generally useful with two-lobe machines generally preferred due to their higher throughput rates. Ring extruders, such as those manufactured by 3+ Extruder GmbH, are also useful and typically comprise a ring of three to twelve small screws or grooved rolls around a static rod or core. The screws co rotate and intermesh on two sides providing good dispersive and distributive mixing as well as the ability to control the residence time of the material in the extruder. The intermeshing design also provides two clean wipes to the screw's shear, mixing, and kneading elements.

The extruder length should be sufficient to allow for melting and intimate admixing of the polymeric components and any additional additives as well as optionally venting of the melt mixture. Extruders as short as five barrel sections may be employed, although longer extruders are also useful.

When preparing blends of poly(arylene ether) solvent, monomers, and other low molecular weight materials are removed from the extruder through the vent system. A particularly useful process to improve the removal of volatile substances from poly(arylene ether) or poly(arylene ether) resin blends includes steam stripping as describe in U.S. Patent No. 5,204,410 to Banevicius et al., U.S. Patent No. 5,102,591 to Hasson et al., U.S. Patent No. 4,994,217 to Banevicius, and 4,992, 222 to Banevicius et al. Steam stripping is typically performed in an extruder comprising ports for the injection of water or steam and sufficient vacuum vent capability to remove the stripped volatiles and water. Water or steam are the preferred stripping agents, and the proportion employed is up to about 15 percent by weight of the polymer composition, to be divided equally, or unequally, among the two or more injection ports located along the length of the extruder barrel. The preferred proportion is from about 0.25 to about 15 weight percent, since an amount within this range is generally very effective for removal of volatiles without burdening the vacuum system. Most preferred is from 0.5 to about 5 weight percent.

Blanketing of the internal free space of the extruder with an inert gas to minimize the exposure of molten polymer to oxygen is also useful to minimize gel and black speck formation. By inert is meant a gas that does not result in oxidation or other chemical reaction with the molten polymeric composition as is generally substantially oxygen-free. Generally, nitrogen is used due to its low cost and ready availability, although other inert gases are also contemplated. Nitrogen (or other inert gas) can be added into one or more of the feeder systems, extruder feed zones, vents, melt filtration systems, and other areas of the extruder in which the molten polymer can come into contact with oxygen.

Also contemplated are extruders comprising one or more side feeders along the extruder barrel suitable to feed additional components to the melt. Additional components include additional resins, functionalizing agents and/or additives.

The extruder is preferably run at temperatures suitable to produce an intimate blend of the components that compose the melt mixture, but low enough to minimize decomposition of the melt mixture. A range of extruder temperatures that may be employed are of about 260°C to about 380°C. Within this range a temperature of less than or equal to about 340°C may be employed, and less than or equal to about 320°C more preferred. Also within this range a temperature of greater than or equal to about 280°C may be employed, and greater than or equal to about 290°C preferred. Within the range of extruder temperatures, the melt mixture generally has a temperature between about 280°C and about 340°C.

The conditions selected to begin and end the melt blending and melt filtering operations are important to control so as to minimize the formation of gels and black specks during the process. When an extruder is utilized, residual material remains that is subjected to extended periods at high temperatures and can lead to formation of gels and black specks. In the practice of the present invention, it is preferred to begin the process with equipment that has been disassembled and cleaned of residual material so as to start with an empty equipment set although in commercial operations, such disassembly is often not feasible. Generally, a material that is compatible with the resin composition that has good thermal and oxidation stability,

e.g., polystyrene, will be used to start the machine. Upon reaching a steady operating state, the composition is adjusted to achieve the desired formulation. It is typical to have an elevated number of gels and black specks during the start-up operation followed by a reduction to a steady state as may be determined via an on-line or off-line quality monitoring system.

When a twin-screw extruder is employed, the extruder operation may be defined by a specific throughput rate of about 0.5 kg/hr/cm^3 to about 8.0 kg/hr/cm^3. The specific throughput rate is defined as the throughput rate of the melt divided by the diameter^3 of the extruder barrel. Within this range a specific throughput rate of less than or equal to about 7.5 kg/hr/cm^3 may be employed, and less than or equal to about 7 kg/hr/cm^3 preferred. Also within this range a throughput rate of greater than or equal to about 3 kg/hr/cm^3 may be employed, and greater than or equal to about 5 kg/hr/cm^3 preferred.

In one embodiment, a melt pump or gear pump is used in combination with the extruder to provide sufficient rate and pressure of a flow of melt through the melt filtration system. The melt pump also provides the capability to control and maintain an even flow of melt through the extruder system resulting in a more uniform polymeric material.

In one embodiment, the poly(arylene ether), poly(alkylene aromatic), and optional additional components may be mixed together prior to the melt blending step. Any known equipment capable of intimately admixing the components may be used, for example, mixers capable of applying shear to the components, conical screw mixers, V-blenders, twin screw compounders, Henschel mixers, ribbon blenders, and the like.

Any suitable melt filtration system or device that can remove particulate impurities from a melt mixture comprising poly(arylene ether), poly(alkenyl aromatic), or a combination of the two, may be used. Preferably, the melt is filtered through a single melt filtration system, although multiple melt filtration systems are contemplated.

Suitable melt filtration systems include filters made from a variety of materials such as, but not limited to, sintered-metal, metal mesh or screen, fiber metal felt, ceramic,

or a combination of the foregoing materials, and the like. Particularly useful filters are sintered metal filters exhibiting high tortuosity, including the sintered wire mesh filters prepared by Pall Corporation and Martin Kurz & Company, Inc.

Any geometry of melt filter may be used including, but not limited to, cone, pleated, candle, stack, flat, wraparound, screens, cartridge, pack disc, as well as a combination of the foregoing, and the like. The selection of the geometry can vary depending on various parameters such as, for example, the size of the extruder and the throughput rate desired as well as the degree of particle filtration that is desired. Preferred materials of construction include stainless steels, titanium, nickel, as well as other metals alloys. Various weaves of wire fabric including plain, dutch, square, and twill can be used. Especially useful are filters that have been designed to minimize internal volume and low flow areas and to withstand repeated cleaning cycles.

The melt filtration system may include a periodic or continuous screen changing filter or batch filters. For example, continuous screen changing filters may include a ribbon of screen filter that is slowly passed into the path of a melt flow in an extruder. The melt mixture passes through the filter and the filter collects particulate impurities within the melt and these impurities are carried out of the extruder with the filter ribbon as it is periodically or continuously renewed with a new section of ribbon.

The pore size of the melt filter may be of any size ranging from about 0.5 micrometer to about 200 micrometers. Within this range, a pore size of less than or equal to about 100 micrometers can be employed, with less than or equal to about 50 micrometers preferred, and less than or equal to about 20 micrometers more preferred. Also within this range a pore size of greater than or equal to about 1 micrometer may be used, with greater than or equal to about 7 micrometers preferred, and greater than or equal to about 15 micrometers more preferred.

The temperature of the melt filtration system is sufficient to maintain the material in a molten state and at a sufficiently low viscosity for the material to pass through the filter without excessive pressure drop. Generally useful temperatures range from about 260°C to about 380°C. Within this range a temperature of less than or equal to

about 340°C may be employed, and less than or equal to about 320°C more preferred. Also within this range a temperature of greater than or equal to about 280°C may be employed, and greater than or equal to about 290°C preferred.

In order to operate the overall melt filtering process in a continuous fashion for long periods of time, it is often desirable to employ a by-pass system for the melt filtration system or device. In a by-pass system, a continuous melt flow is maintained and redirected into a reserve melt filtration system or device. The by-pass system can be operated by a series of automated valves that have been set to engage at a pre-determined value, e.g., predetermined pressure drop or after a predetermined amount of material has been filtered, or can be interconnected with an in-line or off-line quality monitoring system, or may be operated or engaged manually. In a preferred embodiment, the process is operated under conditions wherein less than a five-fold, more preferably less that a three-fold, pressure drop is observed as compared to the initial pressure drop obtained with a clean filtration system. Operation of the melt filtering process in a continuous fashion for long periods of time generally helps to minimize formation of gels and black specks formed during the start-up and shut-down operations and enables a more steady state process to be achieved. Processed materials obtained during the start-up and shut-down operations that are outside the desired particulate level may be reprocessed to avoid wasted material.

The filtered polymeric material obtained is preferably substantially free of visible particulates. "Substantially free of visible particulate impurities" means that a ten gram sample of polymeric material dissolved in fifty milliliters of chloroform ($CHCl_3$) exhibits fewer than five visible specks when viewed with the aid of a light box. As previously explained, particles visible to the naked eye are typically those greater than 30 micrometers in diameter.

In a preferred embodiment, the filtered polymeric material recovered from the extruder is substantially free of particulate impurities greater than about 20 micrometers, more preferably greater than about 10 micrometers. "Substantially free of particulate impurities greater than about 20 (or 10) micrometers" means that of a forty gram sample of polymeric material dissolved in 400 milliliters of $CHCl_3$, the

number of particulates per gram having an average diameter of about 20 (or 10) micrometers is less than 200, as measured by a Pacific Instruments ABS2 analyzer based on the average of five samples of twenty milliliter quantities of the dissolved polymeric material that is allowed to flow through the analyzer at a flow rate of one milliliter per minute (plus or minus five percent).

In another embodiment, the filtered polymeric material has less than 10 black specks, preferably less than 5 black specks, and more preferably less than 2 black specks, larger than 100 micrometers in average diameter size per 15 grams of filtered polymeric material. In another embodiment, the filtered polymeric material has less than 5 black specks, preferably less than 2 black specks, and more preferably no black specks, larger than 140 micrometers in average diameter size per 15 grams of filtered polymeric material. In another embodiment, the filtered polymeric material has less than 100 black specks, preferably less than 75 black specks, and more preferably less than 50 black specks, within the 20 to 100 micrometer average diameter range per 15 grams of filtered polymeric material.

Upon extrusion, the filtered polymeric material may be pelletized by methods known in the art. For example, strands of filtered polymeric material extruded from an extruder or similar device, may be cooled in clean water baths or cooled by water spray and then chopped into pellets. The water, prior to its use in the bath or spray, may be filtered to remove impurities. Likewise the water may be recycled and filtered during the recycle loop. The water is typically filtered to remove particles greater than about 20 micrometers. De-ionized filtered water is also generally preferred to remove ionic impurities that may adhere to the filtered material. When a water bath or spray is employed to regulate the temperature of the extrudate prior to cutting, the extrudate temperature is preferably adjusted to minimize the formation of dust and to help provide a relatively uniform pellet size. When a water bath and/or water spray is utilized, an air knife is typically employed prior to cutting the extrudate. It is preferred to use filtered air in the air knife to avoid contaminating the hot strands with micrometer-sized particles. A preferred strand temperature is less than about 130°C, with less than about 90°C often more preferred.

Typically, pellets are approximately 2-3 mm in size although smaller or larger pellets may also be desired. Although a variety of devices may be employed to cut the extrudate into the desired pellet size, cutting devices having multiple rotating blades and metal rollers, for example, stainless steel rollers, are often preferred. Use of rubber rollers can lead to contamination of the filtered polymeric material. Pellet screeners are often preferably employed to remove undesired pellets that are too small or too large. When screeners and other devices, such as transfer systems, are employed for handling the pellets, equipment having elastomer components that may lead to pellet contamination are generally avoided. The pellets may be dried using techniques standard in the art including centrifugal dryers, batch or continuous oven dryers, fluid beds, and the like. Optionally, the filtered polymeric material may be transferred and isolated as pellets in a "clean room" using, for example, HEPA air filtration to prevent contamination from the surroundings. Collection and handling of the filtered resin material in a Class 100 environment is typically preferred. The pellets may be packaged in a variety of containers provided that such containers do not lead to contamination of the filtered polymeric material. In a preferred embodiment, the pellets are vacuum packaged to draw the container tightly around the contents to reduce the shifting and breakage of the pellets into finer particles during handling and transport. Additionally, vacuum packaging enables an oxygen-free and contaminant-free environment to be maintained.

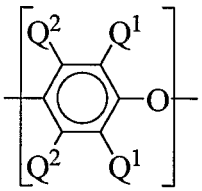
One preferred pelletization method employs an underwater die-face pelletizer system. Another preferred pelletization method employs a water ring pelletizer system. A suitable method of pelletizing is generally described in United States Pat. No. 6,372,175. Useful pelletizing machines, including die-face pelletizers, are generally described in United States Pat. Nos. 3,973,890, 4,421,470, and 5,607,700.

Rather than extruding pellets, the filtered polymeric material may be extruded as fibers, tubes, films, or sheets by appropriate choice of the die assembly.

Various in-line and off-line monitors may also be employed to judge the quality of the filtered material during the filtering process. Such monitors often employ light or laser sensing devices to detect visible specks in the extrudate and/or in the pellets.

The monitors can be interconnected with the operation of the processing equipment and programmed to automatically adjust the process based upon predetermined criteria. Likewise, the monitors may sound alarms to alert the operators based on the predetermined criteria.

The term poly(arylene ether) includes polyphenylene ether (PPE) and poly(arylene ether) copolymers; graft copolymers; poly(arylene ether) ether ionomers; and block copolymers of alkenyl aromatic compounds, vinyl aromatic compounds, and poly(arylene ether), and the like; and combinations comprising at least one of the foregoing; and the like. Poly(arylene ether)s per se, are known polymers comprising a plurality of structural units of the formula (I):



(I)

wherein for each structural unit, each Q^1 is independently halogen, primary or secondary lower alkyl (e.g., alkyl containing up to 7 carbon atoms), phenyl, haloalkyl, aminoalkyl, hydrocarbonoxy, or halohydrocarbonoxy wherein at least two carbon atoms separate the halogen and oxygen atoms, or the like; and each Q^2 is independently hydrogen, halogen, primary or secondary lower alkyl, phenyl, haloalkyl, hydrocarbonoxy, or halohydrocarbonoxy wherein at least two carbon atoms separate the halogen and oxygen atoms, or the like. It will be understood that the term "haloalkyl" includes alkyl groups substituted with one or more halogen atoms, including partially and fully halogenated alkyl groups. Preferably, each Q^1 is alkyl or phenyl, especially C_{1-4} alkyl, and each Q^2 is hydrogen or C_{1-4} alkyl.

Both homopolymer and copolymer poly(arylene ether) are included. The preferred homopolymers are those containing 2,6-dimethylphenylene ether units. Suitable copolymers include random copolymers containing, for example, such units in combination with 2,3,6-trimethyl-1,4-phenylene ether units or copolymers derived from copolymerization of 2,6-dimethylphenol with 2,3,6-trimethylphenol. Also

included are poly(arylene ether) containing moieties prepared by grafting vinyl monomers or polymers such as polystyrenes, as well as coupled poly(arylene ether) in which coupling agents such as low molecular weight polycarbonates, quinones, heterocycles and formals undergo reaction in known manner with the hydroxy groups of two poly(arylene ether) chains to produce a higher molecular weight polymer. Poly(arylene ether)s used herein may further include combinations comprising at least one of the above. Preferred poly(arylene ether)s are poly(2,6-dimethylphenylene ether) and poly(2,6-dimethylphenylene ether-co-2,3,6-trimethylphenylene ether) such as those described in U.S. Patent No. 6,407,200 to Singh et al. and U.S. Patent No. 6,437,084 to Birsak et al.

The poly(arylene ether) generally has a number average molecular weight of about 3,000-40,000 atomic mass units (amu) and a weight average molecular weight of about 20,000-80,000 amu, as determined by gel permeation chromatography. The poly(arylene ether) may have an intrinsic viscosity (IV) of about 0.10 to about 0.60 deciliters per gram (dl/g), as measured in chloroform at 25°C. Within this range an IV of less than or equal to about 0.48 preferred, and less than or equal to about 0.40 more preferred. Also preferred within this range is an IV of greater than or equal to about 0.29, with greater than or equal to about 0.33 dl/g more preferred. It is also possible to utilize a high intrinsic viscosity poly(arylene ether) and a low intrinsic viscosity poly(arylene ether) in combination. Determining an exact ratio, when two intrinsic viscosities are used, will depend somewhat on the exact intrinsic viscosities of the poly(arylene ether) used and the ultimate physical properties that are desired.

Suitable poly(arylene ether)s include, but are not limited to, poly(2,6-dimethyl-1,4-phenylene ether); poly(2,3,6-trimethyl-1,4-phenylene) ether; poly(2,6-dimethylphenylene ether-co-2,3,6-trimethylphenylene ether); poly(2,6-diethyl-1,4-phenylene) ether; poly(2-methyl-6-propyl-1,4-phenylene) ether; poly(2,6-dipropyl-1,4-phenylene) ether; poly(2-ethyl-6-propyl-1,4-phenylene)ether; poly(2,6-dilauryl-1,4-phenylene) ether; poly(2,6-diphenyl-1,4-phenylene) ether; poly(2,6-dimethoxy-1,4 phenylene) ether; poly(2,6-diethoxy-1,4-phenylene) ether; poly(2-methoxy-6-ethoxy-1,4-phenylene) ether; poly(2-ethyl-6-stearyloxy-1,4-phenylene) ether; poly(2,6-dichloro-1,4-phenylene) ether; poly(2-methyl-6-phenyl-1,4-phenylene)

ether; poly(2-ethoxy-1,4-phenylene) ether; poly(2-chloro-1,4-phenylene) ether; poly(2,6-dibromo-1,4-phenylene) ether; poly(3-bromo-2,6-dimethyl-1,4-phenylene) ether; or a mixture of the foregoing poly(arylene ether)s.

Suitable base titratable functionalized poly(arylene ether) resins include, but are not limited to, those prepared via reaction with an appropriate acid or anhydride functionalization agent. For example those prepared by melt reaction of poly(arylene ether) with alpha, beta unsaturated carbonyl compounds, including maleic anhydride, maleic acid, fumaric acid, citraconic anhydride, citraconic acid, itaconic anhydride, itaconic acid, aconitic anhydride, aconitic acid, and their esters and amines; alpha-hydroxy carbonyl compounds including carboxylic acids such as citric acid and maleic acid; derivatives of 5-hydroxybenzene-1,2,4- tricarboxylic anhydride, such as the 5-acetyl-derivative or a 4-ester- derivative such as the phenyl ester; trimellitic anhydride aryl esters, including trimellitic anhydride phenyl salicylate; and reaction products and combinations comprising at least one of the foregoing, among others, can be employed. Alternatively, poly(arylene ether) may be functionalized with acidic or latent acidic groups in a suitable solvent. Examples of such processes include metallation of poly(arylene ether) in tetrahydrofuran (THF) followed by quenching with carbon dioxide or capping of poly(arylene ether) in toluene solution with trimellitic anhydride acid chloride. Typically, less than or equal to about 10 wt % functionalization agent can be used (based on the weight of the poly phenylene ether and the agent), with less than or equal to about 6 wt % preferred, and about 1.5 wt % to about 4 wt % especially preferred.

In one embodiment, the poly(arylene ether) comprises a capped poly(arylene ether). The capping may be used to reduce the oxidation of terminal hydroxy groups on the poly(arylene ether) chain. The terminal hydroxy groups may be inactivated by capping with an inactivating capping agent via an acylation reaction, for example. The capping agent chosen is desirably one that results in a less reactive poly(arylene ether) thereby reducing or preventing crosslinking of the polymer chains and the formation of gels or black specks during processing at elevated temperatures. Suitable capping agents include, for example, esters of salicylic acid, anthranilic acid, or a substituted derivative thereof, and the like; esters of salicylic acid, and especially

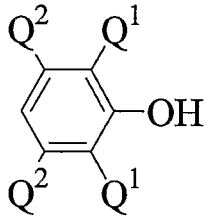
salicylic carbonate and linear polysalicylates, are preferred. As used herein, the term "ester of salicylic acid" includes compounds in which the carboxy group, the hydroxy group, or both have been esterified. Suitable salicylates include, for example, aryl salicylates such as phenyl salicylate, acetylsalicylic acid, salicylic carbonate, and polysalicylates, including both linear polysalicylates and cyclic compounds such as disalicylide and trisalicylide. The preferred capping agents are salicylic carbonate and the polysalicylates, especially linear polysalicylates. When capped, the poly(arylene ether) may be capped to any desirable extent up to 80 percent, more preferably up to about 90 percent, and even more preferably up to 100 percent of the hydroxy groups are capped. Suitable capped poly(arylene ether) and their preparation are described in United States Pat. Nos. 4,760,118 to White et al. and 6,306,978 to Braat et al.

Capping poly(arylene ether) with polysalicylate is also believed to reduce the amount of aminoalkyl terminated groups present in the poly(arylene ether) chain. The aminoalkyl groups are the result of oxidative coupling reactions that employ amines in the process to produce the poly(arylene ether). The aminoalkyl group, ortho to the terminal hydroxy group of the poly(arylene ether), is susceptible to decomposition at high temperatures. The decomposition is believed to result in the regeneration of primary or secondary amine and the production of a quinone methide end group, which may in turn generate a 2,6-dialkyl-1-hydroxyphenyl end group. Capping of poly(arylene ether) containing aminoalkyl groups with polysalicylate is believed to remove such amino groups to result in a capped terminal hydroxy group of the polymer chain and the formation of 2-hydroxy-N,N-alkylbenzamine (salicylamide). The removal of the amino group and the capping provides a poly(arylene ether) that is more stable to high temperatures, thereby resulting in fewer degradative products, such as gels or black specks, during processing of the poly(arylene ether).

Based upon the foregoing, it will be apparent to those skilled in the art that the contemplated poly(arylene ether) resin may include many of those poly(arylene ether) resins presently known, irrespective of variations in structural units or ancillary chemical features.

The poly(arylene ether)s are typically prepared by the oxidative coupling of at least

one monohydroxyaromatic compound in the presence of a catalyst system and solvent. There is no particular limitation on the monohydric phenol used in the poly (arylene ether) synthesis. Suitable monohydroxyaromatic compounds include those according to the following formula (II)



(II)

wherein each Q^1 is independently halogen, primary or secondary lower alkyl (e.g., alkyl containing up to 7 carbon atoms), phenyl, haloalkyl, aminoalkyl, hydrocarbonoxy, or halohydrocarbonoxy wherein at least two carbon atoms separate the halogen and oxygen atoms, or the like; and each Q^2 is independently hydrogen, halogen, primary or secondary lower alkyl, phenyl, haloalkyl, hydrocarbonoxy, or halohydrocarbonoxy wherein at least two carbon atoms separate the halogen and oxygen atoms, or the like. Preferably, each Q^1 is alkyl or phenyl, especially C_{1-4} alkyl, and each Q^2 is hydrogen or C_{1-4} alkyl. Preferred monohydroxyphenols include 2,6-dimethylphenol and 2,3,6-trimethylphenol.

In one embodiment, the monohydroxyphenol is 2,6-dimethylphenol having a purity of greater than about 99 weight percent, preferably greater than 99.67 weight percent, and more preferably greater than 99.83 weight percent. The 2,6-dimethylphenol preferably comprises less than about 0.004 weight percent phenol and more preferably less than 0.003 weight percent phenol. It is preferred that the 2,6-dimethylphenol contain less than about 0.12 weight percent cresol and more preferably less than 0.087 weight percent cresol. Cresol includes, for example, o-cresol, m-cresol, p-cresol, or a combination comprising at least one of the foregoing cresols. In a preferred embodiment, the 2,6-dimethylphenol contains less than about 0.107 weight percent other mono-, di- and/or trialkylphenols and preferably less than 0.084 weight percent. The other mono-, di- and/or trialkylphenols may include, for example, 2,3,6-trimethylphenol, 2,6-ethylmethylphenol, 2-ethylphenol, 2,4,6-trimethylphenol, or a combination comprising at least one of the foregoing other mono-, di- and/or

trialkylphenols. In another preferred embodiment, the 2,6-dimethylphenol preferably comprises less than about 0.072 weight percent of another dimethylphenol besides 2,6-dimethylphenol, more preferably less than about 0.055 weight percent of another dimethylphenol. The other dimethylphenol may be 2,4-dimethylphenol, 2,3-dimethylphenol, 2,5-dimethylphenol, 3,5-dimethylphenol, 3,4-dimethylphenol, or a combination comprising at least one of the foregoing dimethylphenols. It is believed that minimizing the amounts of phenol, cresol, other dimethylphenols, and mono-, di-, and/or trialkylphenols in the 2,6-dimethylphenol monomer leads to a reduction in undesired branching or chain stopping reactions and helps maintain the integrity of the resulting poly(phenylene ether) physical properties.

The oxidative coupling of the monohydric phenol uses an oxygen-containing gas, which is typically oxygen (O_2) or air, with oxygen being preferred.

Suitable organic solvents for the oxidative coupling include aliphatic alcohols, ketones, aliphatic and aromatic hydrocarbons, chlorohydrocarbons, nitrohydrocarbons, ethers, esters, amides, mixed ether-esters, sulfoxides, and the like, and combinations comprising at least one of the foregoing organic solvents, providing they do not interfere with or enter into the oxidation reaction. Preferred solvents include C_6-C_{18} aromatic hydrocarbons such as benzene, toluene, and xylene; halogenated hydrocarbons such as dichloromethane, and chloroform; and halogenated aromatic hydrocarbons such as chlorobenzene and dichlorobenzene.

The solvent may comprise, in addition to a C_6-C_{18} aromatic hydrocarbon, a C_3-C_8 aliphatic alcohol that is a poor solvent for the poly(arylene ether), such as, for example, n-propanol, isopropanol, n- butanol, t-butanol, n-pentanol, and the like, and combinations comprising at least one of the foregoing C_3-C_8 aliphatic alcohols. The solvent may further comprise, in addition to a C_6-C_{18} aromatic hydrocarbon and a C_3-C_8 aliphatic alcohol, methanol or ethanol, which act as an anti-solvent for the poly(arylene ether). The C_6-C_{18} aromatic hydrocarbon, the C_3-C_8 aliphatic alcohol, and the methanol or ethanol may be combined in any proportion, but in some embodiments, it is preferred that the solvent comprise at least about 50 weight percent of the C_6-C_{18} aromatic hydrocarbon.

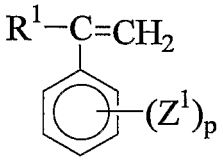
Useful catalyst systems typically contain at least one heavy metal compound such as a copper, manganese or cobalt compound, usually in combination with various other materials. Suitable catalyst systems include cuprous chloride, cupric chloride, cuprous bromide, cupric bromide, cuprous sulfate, cupric sulfate, cuprous tetraamine sulfate, cupric tetraamine sulfate, cuprous acetate, cupric acetate, cuprous propionate, cupric butyrate, cupric laurate, cuprous palmitate and cuprous benzoate; and similar manganese salts and cobalt salts. Instead of direct addition of the above-exemplified metal salt, it is also possible to add a metal or a metal oxide and an inorganic acid, organic acid or an aqueous solution of such an acid and form the corresponding metal salt or hydrate.

The catalyst systems may also be complexed with a mono- or dialkylamine, aromatic amines or N,N'-dialkylalkylenediamines. Non-limiting examples of suitable primary, secondary or tertiary amines include mono- and dimethylamine, mono- and diethylamine, mono- and dipropylamine, mono- and dibutylamine, mono- and dibenzylamine, mono- and dicyclohexylamine, mono- and diethanolamine, methylethylamine, methylpropylamine, methylcyclohexylamine, ethylisopropylamine, benzylmethylamine, octylchlorobenzylamine, methylphenethylamine, benzylethylamine, dimethylbutylamine, N,N'-dialkylethylenediamines such as N,N'-di-tert-butylethylenediamine, and N,N'-di-isopropylethylenediamine, N,N,N'- trialkylethylenediamines, N,N'-dialkylpropylenediamines and N,N,N'- trialkylpropylenediamines.

Known processes to prepare poly(phenylene ether)s include European patent documents EP 1167421A2; EP1167419A2; and EP1167420A1, all of which are incorporated herein by reference. Further methods for preparing poly(phenylene ether)s are described, for example, in United States Patent Nos. 6,407,200, 5,250,486; 5,017,655; 4,092,294; 4,083,828; 4,054,553; 3,962,181; 3,838,102; 3,733,299; 3,661,848; 3,642,699; 3,639,656; 3,365,422; 3,306,875; and 3,306,874. Based upon the foregoing, it will be apparent to those skilled in the art that the contemplated poly(arylene ether) may prepared by all methods presently known, irrespective of variations in processing conditions, reagents, or catalysts.

In one embodiment, the poly(arylene ether) is isolated by precipitation and preferably has a copper content of less than about 15 parts per million and more preferably less than 5 parts per million. Additionally, the precipitated poly(phenylene ether) comprises an amount of titratable amine content of less than about 1.27 weight percent and preferably less than 1.18 weight percent. A titratable amine content that is too high results in a poly(phenylene ether) having a strong odor, while too little amine content may result in a polymer having poor mechanical properties. In another embodiment, the poly(arylene ether) reaction mixture is filtered to remove, at least in part, gels and other particulates prior to isolation of the poly(arylene ether).

The term poly(alkenyl aromatic) resin as used herein includes polymers prepared by methods known in the art including bulk, suspension, and emulsion polymerization, which contain at least 25% by weight of structural units derived from an alkenyl aromatic monomer having the structure (III)



(III)

wherein R^1 is hydrogen, C_1-C_8 alkyl, or halogen; Z^1 is vinyl, halogen or C_1-C_8 alkyl; and p is 0 to 5. Preferred alkenyl aromatic monomers include styrene, chlorostyrene, and vinyltoluene. The poly(alkenyl aromatic) resins include homopolymers of an alkenyl aromatic monomer; random copolymers of an alkenyl aromatic monomer, such as styrene, with one or more different monomers such as acrylonitrile, butadiene, alpha-methylstyrene, ethylvinylbenzene, divinylbenzene and maleic anhydride; and rubber-modified poly(alkenyl aromatic) resins comprising blends and/or grafts of a rubber modifier and a homopolymer of an alkenyl aromatic monomer (as described above), wherein the rubber modifier may be a polymerization product of at least one C_4-C_{10} nonaromatic diene monomer, such as butadiene or isoprene, and wherein the rubber-modified poly(alkenyl aromatic) resin comprises about 98 to about 70 weight percent of the homopolymer of an alkenyl aromatic monomer and about 2 to about 30 weight percent of the rubber modifier, preferably about 88 to about 94 weight percent of the homopolymer of an alkenyl aromatic monomer and about 6 to about 12 weight

percent of the rubber modifier. These rubber modified polystyrenes include high impact polystyrene (commonly referred to as HIPS).

The poly(alkenyl aromatic) resins also include non-elastomeric block copolymers, for example diblock, triblock, and multiblock copolymers of styrene and one or more polyolefins. Non-elastomeric block copolymer compositions of styrene and butadiene can also be used that have linear block, radial block, or tapered block copolymer architectures wherein the butadiene component is present up to about 35 weight percent. They are commercially available from such companies as Atofina as under the trademark FINACLEAR and Chevron Phillips Chemical Company under the trademark K-RESINS.

The poly(alkenyl aromatic) resins may also include block copolymers of styrene-polyolefin-methyl methacrylate, especially poly(styrene-*beta*-1,4-butadiene-*beta*-methyl methacrylate (SBM) available from Atofina comprising blocks of polystyrene, 1,4-polybutadiene, and syndiotactic polymethyl methacrylate. SBM block copolymers available from Atofina include AF-X223, AF-X333, AF-X012, AF-X342, AF-X004, and AF-X250.

A preferred poly(alkenyl aromatic) is a homopolymer of the alkenyl aromatic monomer (III) wherein R^1 is hydrogen, lower alkyl or halogen; Z^1 is vinyl, halogen or lower alkyl; and p is from 0 to 5. A particularly preferred homopolymer of an alkenyl aromatic monomer is the homopolymer derived from styrene (i.e., homopolystyrene). The homopolystyrene preferably comprises at least 99% of its weight, more preferably 100% of its weight, from styrene.

The stereoregularity of the poly(alkenyl aromatic) resin may be atactic or syndiotactic. Highly preferred poly(alkenyl aromatic) resins include atactic and syndiotactic homopolystyrenes. Suitable atactic homopolystyrenes are commercially available as, for example, EB3300 from Chevron, and P1800 from BASF. Atactic homopolystyrenes are sometimes referred to herein as "crystal polystyrene" resins. Useful syndiotactic polystyrene resins (SPS) are available from The Dow Chemical Company under the QUESTRA trademark.

The poly(alkenyl aromatic) may have a number average molecular weight of about 20,000-100,000 atomic mass units (amu) and a weight average molecular weight of about 10,000-300,000 amu.

The filtered polymeric material obtained may comprise poly(arylene ether) in an amount of about 90 to about 10 weight percent and poly(alkenyl aromatic) in an amount of about 10 to about 90 weight percent, based on the total weight of the poly(alkenyl aromatic) and poly(arylene ether) resins. Within this range the amount of poly(arylene ether) may be less than or equal to about 80 weight percent, less than or equal to about 70 weight percent preferred, and less than or equal to about 60 weight percent more preferred. Also preferred within this range is an amount of poly(arylene ether) greater than or equal to about 20 weight percent, with greater than or equal to about 30 weight percent more preferred, and greater than or equal to about 40 weight percent even more preferred. Within this range the amount of poly(alkenyl aromatic) may be less than or equal to about 80 weight percent, less than or equal to about 70 weight percent preferred, and less than or equal to about 60 weight percent more preferred. Also preferred within this range is an amount of poly(alkenyl aromatic) greater than or equal to about 20 weight percent, greater than or equal to about 30 weight percent preferred, and greater than or equal to about 40 weight percent more preferred.

The polymeric composition may further comprise various impact modifiers for improving the ductility of the composition. Useful impact modifiers include the elastomeric block copolymers, for example, A-B-A triblock copolymers and A-B diblock copolymers as well as other multiblocks such as A-B-A-B and B-A-B-A-B block copolymers. These various block copolymers are thermoplastic rubbers comprised of alkenyl aromatic blocks that are generally styrene blocks and rubber blocks, e.g., a butadiene block, which may be partially or totally hydrogenated. Examples of typical species of block copolymers include polystyrene-polybutadiene (SBR), polystyrene-poly(ethylene-propylene) (SEP), polystyrene-polyisoprene, poly(alpha-methylstyrene)-polybutadiene, polystyrene-polybutadiene-polystyrene (SBS), polystyrene-poly(ethylene-butylene)-polystyrene (SEBS), polystyrene-polyisoprene-polystyrene and poly(alpha-methylstyrene)-polybutadiene-poly(alpha-

methylstyrene), as well as the selectively hydrogenated versions thereof. In order to retain physical properties after long term elevated temperature aging or after high processing temperatures, the partially or totally hydrogenated block copolymers are often preferred. Block sizes can also be adjusted in order to maintain optical clarity when formed into various articles. Useful block copolymers are available commercially from a number of sources, including Phillips Petroleum Co., LTD. under the trademark SOLPRENE, Kraton Polymers under the trademark KRATON, Dexco Polymers LP under the tradename VECTOR, Asahi Kasei Chemical Corporation under the tradenames ASAFLEX and TUFTEC, and Kuraray Co., LTD. under the trademark SEPTON.

Other useful impact modifiers include the so-called core-shell polymers built up from a rubber-like core on which one or more shells have been grafted. The core usually consists substantially of an acrylate rubber, butadiene rubber, or silicon-based rubber. One or more shells have been grafted on the core. Usually these shells are built up for the greater part from a vinylaromatic compound and/or a vinylcyanide and/or an alkyl(meth)acrylate and/or (meth)acrylic acid. In a preferred embodiment, the shell is mainly derived from vinylaromatic compound, preferably styrene and/or alpha-methylstyrene, in order to provide good compatibility between the impact modifier and the polymer composition. The core and/or the shell(s) often comprise multi-functional compounds that may act as a cross-linking agent and/or as a grafting agent. These polymers are usually prepared in several stages using well-known emulsion chemistry. The particle size and composition can be adjusted to maintain optical clarity and enhanced ductility when formed into various articles. The core-shell polymers are available commercially from a number of sources, including from Rohm and Haas Company under the tradename PARALOID.

Additional impact modifiers include the block and graft copolymers of poly(arylene ether) and polysiloxanes. Generally the block copolymers are more preferred and have A-B and A-B-A structures wherein the A blocks represent the poly(arylene ether). The preparation of these copolymers is well-known in the art and typically involves redistribution of an hydroxy terminated siloxane with a poly(arylene ether). The molecular weights of each component, hydroxy terminated siloxane with a

poly(arylene ether), as well as their weight ratios can be readily optimized based, at least in part, on the desired physical properties desired in the filtered polymeric composition.

The impact modifier may be present in the polymeric composition in an amount effective to increase the ductility of the composition and is typically used in an amount up to about 12.0 weight percent, or, more preferably, in an amount of about 6.0 weight percent, wherein the weight percents are based on the total weight of the polymeric composition.

Also contemplated are filtered polymeric materials further comprising other resins in addition to the poly(arylene ether) and/or the poly(alkylene aromatic). Examples of such other resins include polyamides, poly(phenylene sulfide)s, polyetherimides, polyolefins, and the like.

The filtered polymeric material may, optionally, further comprise an additive selected from flame retardants, mold release agents and other lubricants, antioxidants, thermal stabilizers, ultraviolet stabilizers, pigments, dyes, colorants, anti-static agents, conductive agents, fillers, and the like, and a combination comprising at least one of the foregoing additives. Selection of particular additives and their amounts may be performed by those skilled in the art. If the additives are present in the polymeric material prior to filtration, the additive should be selected so as to not interfere with the particular filtration system chosen for the method. Optionally, additives may be added to the filtered polymeric material after the filtration step by methods known in the art, either prior to or post isolation of the filtered polymeric material. Furthermore, for some applications the presence of the additives must not adversely affect the surface quality or radial tilt properties of articles molded from the material. Special processing conditions during molding may be required to ensure an adequately smooth surface when molding filled articles.

Examples of pigments and dyes known to the art include those described in the chapter "Colorants" in "Plastic Additives Handbook, 4th Edition" R. Gachter and H. Muller (eds.), P.P. Klemchuck (assoc. ed.) Hansen Publishers, New York 1993.

Colorants include organic and inorganic pigments and dyes. Suitable inorganic colorants include carbon black, iron oxide, titanium dioxide, zinc oxide, zinc sulfide, and the like. Suitable organic colorants include those from the following chemical classes: anthanthrone, anthraquinone, benzimidazolone, diketopyrrolo-pyrrole, dioxazine, diazo, indanthrone, isoindoline, isoindolinone, naphthol, perinone, perylene, phthalocyanine, pyranthrone, quinacridone, quinophthalone, and the like.

The filtered polymeric material may also comprise flame retardants including non-halogenated flame retardants such as phosphate flame retardants, and halogenated flame retardants. Examples of suitable flame retardants include those found in the "Plastic Additives Handbook" under the chapter "Flame Retardants".

In one embodiment, prior to melt filtration, the poly(arylene ether) and/or poly(alkenyl aromatic) may be dissolved in a suitable solvent to form a solution which may be filtered through one or more solution filtration systems to form a filtrate. The poly(arylene ether) and/or poly(alkenyl aromatic) may be isolated from the filtrate prior to its introduction to the extruder employed to form the melt. Optionally the filtrate may be concentrated to a weight percent solids to form a concentrate which is then fed to the extruder comprising the melt filtration system. A weight percent solids of the concentrate comprising poly(arylene ether) and/or poly(alkenyl aromatic) may range from about 10 to about 99 weight percent based on the total weight of polymeric material and solvent.

Suitable solvents for use in the solutions to be filtered from the above-described embodiment include a halogenated aromatic solvent, a halogenated aliphatic solvent, a non-halogenated aromatic solvent, a non-halogenated aliphatic solvent, or a mixture thereof. Suitable halogenated aromatic solvents include, but are not limited to, halobenzenes, ortho-dichlorobenzene, chlorobenzene, and the like. Suitable halogenated aliphatic solvents include, but are not limited to, chloroform, methylene chloride, 1,2-dichloroethane, and the like. Suitable non-halogenated aromatic solvents include, but are not limited to, benzene, toluene, xylenes, anisole, nitrobenzene, and the like. Suitable non-halogenated aliphatic solvents include, but are not limited to, acetone, ethyl acetate, and the like. The solvent may be the same as

the polymerization solvent employed in the process of producing a poly(arylene ether) resin.

Suitable solution filtration systems include filters made from a variety of materials such as, but not limited to, sintered-metal fibers, cloth, polymeric fiber, natural fiber, paper, metal mesh, pulp, ceramic, or a combination of the foregoing materials, and the like.

The geometry of the filter employed in the solution filtration system may be cone, pleated, candle, stack, flat, wraparound, or a combination of the foregoing, and the like.

The pore size of the filter employed in the solution filtration system may be of any size ranging from 0.01 to 100 micrometer, or greater. Within this range, a pore size of less than or equal to about 50 micrometers can be employed, with less than or equal to about 20 micrometers preferred, and less than or equal to about 15 micrometers more preferred. Also preferred within this range is a pore size of greater than or equal to about 0.1 micrometer, with greater than or equal to about 3 micrometers more preferred, and greater than or equal to about 5 micrometers especially preferred.

Suitable solution filtration processes may include gravity filtration, pressure filtration, vacuum filtration, batch filtration, continuous filtration, or a combination of the foregoing filtration methods, and the like.

There is no particular limitation on the method by which the poly(arylene ether) and/or poly(alkenyl aromatic) may be isolated from the filtrate. Generally preferred are those isolation methods and associated processes that do not re-introduce a significant number of impurities and black specks into the filtered material. Suitable processes known in the art to remove a solvent from a resin are generally applicable. Such processes include, but are not limited to, precipitation, distillation, spray drying, film evaporation, devolatilization, and the use of flash vessels to evaporate the solvent. The several processes described herein for isolation may be used alone or in combination. When isolated, the poly(arylene ether) and/or poly(alkenyl aromatic)

may be in the form of a powder, pellet, flake or a feed directly from the isolation process to the extruder comprising the melt filtration system.

Many of the isolation processes described above may be used to concentrate the filtrate without entirely removing the solvent from the filtrate, but instead to provide a concentrate having an increased percent solids which may be fed into the extruder employed for melt filter. When a concentrate is fed into the extruder, the extruder is preferably a devolatilization extruder capable of removing solvent in the melt.

Devolatilizing extruders and processes are known in the art and typically involve a twin-screw extruder equipped with multiple venting sections for solvent removal. The devolatilizing extruders most often contain screws with numerous types of elements adapted for such operations as simple feeding, devolatilization and liquid seal formation. These elements include forward-flighted screw elements designed for simple transport, and reverse-flighted screw and cylindrical elements to provide intensive mixing and/or create a seal. Particularly useful are counterrotating, non-intermeshing twin screw extruders, in which one screw is usually longer than the other to facilitate efficient flow through the die of the material being extruded. Such equipment is available from various manufacturers including Welding Engineers, Inc.

In one embodiment, isolation comprises pre-concentration of the filtrate (partial evaporation of the solvent) and devolatilization extrusion steps. During pre-concentration, the major part of the solvent is removed by evaporation, preferably at an elevated temperature, for example, in the range from about 150 to about 300°C, more preferably in the range of about 180 to about 260°C, and/or elevated pressure, for example in the range from about 2 to about 75 bar, more preferably in the range of about 5 to about 50 bar. Pre-concentration removes about 1.0 to 99 percent of the solvent present in the filtrate. Within this range preferably less than or equal to about 90 percent, more preferably less than or equal to about 80 percent of the solvent is removed. Pre-concentration is followed by devolatilization extrusion to remove the residual solvent.

If a pre-concentration step is used before the devolatilization step, the filtrate is preferably concentrated to about 10 to about 99 weight percent solids level based on the total of solvent and polymeric material. Concentrated solutions of the filtrate may be isolated from the remaining solvent by a devolatilization process.

In another embodiment, a method of purifying a polymeric material comprises melt blending poly(arylene ether) and poly(alkenyl aromatic) in a twin screw extruder to form a melt; and melt filtering the melt through a melt filtration system to produce a filtered polymeric material; wherein the extruder has a specific throughput rate of about 0.5 kg/cm^3 to about 8 kg/cm^3.

In one embodiment, a method of purifying a polymeric material comprises melt blending about 60 to about 30 weight percent of poly(phenylene ether) and about 40 to about 70 weight percent of polystyrene based on the total weight of poly(phenylene ether) and polystyrene in an extruder to form a melt; and melt filtering the melt through a melt filtration system to produce a filtered polymeric material, wherein the filtered polymeric material is substantially free of visible particulate impurities; and wherein the melt has an average residence time in the extruder of less than or equal to about 1 minute.

In yet another embodiment, articles are made from the filtered polymeric materials prepared by any one of the methods presented herein. Particularly preferred articles include data storage media, such as but not limited to, optical, magneto, or magneto-optical data storage media. Such media include compact discs, re-writable compact discs, digital versatile disks, high density disks for data archival technology (DVR, such as BLU-RAY Disc), and the like.

In a preferred embodiment, the substrate layer for storage media are made from the filtered polymeric materials prepared by any one of the methods presented herein. These storage media are preferably capable of being read with a light source having a wave length of 405 nm and preferably, having an objective-lens numerical aperture of 0.85. Alternatively, these storage media are preferably capable of being read with a light source having a wave length of 450 nm and an objective-lens numerical aperture

of 0.65. Media having decreased wave lengths and a higher objective-lens numerical aperture to increase the overall capacity of the storage media are also contemplated; however, with possible decreased optical tolerances.

The articles may be made by a variety of molding and processing techniques. Suitable techniques to form articles include injection molding, foaming processes, injection-compression, rotary molding, two shot molding, microcellular molding, film casting, extrusion, press molding, blow molding, direct molding (see generally WO 02/43943 to Adedeji et al.), and the like. A preferred technique is injection molding.

In one embodiment, the substrate layer is prepared by injection molding the filtered polymeric composition of poly(arylene ether) and poly(alkenyl aromatic) to form a disk substrate having reduced molded in stresses through the control of the injection molding parameters. Reduced molded in stresses in the substrate provides a disk assembly having increased dimensional stability, thereby exhibiting minimal tilt when the assembly is exposed to elevated temperatures. When injection molding a filtered polymeric composition of poly(arylene ether) and poly(alkenyl aromatic), a melt temperature of about 330 to about 370°C may be used. Within this range a melt temperature of greater than or equal to about 340°C is preferred, with greater than or equal to about 350°C more preferred. Also within this range a melt temperature of less than or equal to about 360°C is preferred, with less than or equal to about 355°C more preferred.

Also within the previous embodiment, a mold temperature of about 90 to about 130°C may be used. Within this range a mold temperature of greater than or equal to about 100°C may be used, with greater than or equal to about 110°C preferred, and with greater than or equal to about 115°C more preferred. Also within this range a mold temperature of less than or equal to about 125°C is preferred, with less than or equal to about 120°C more preferred. A clamp tonnage of greater than or equal to about 12 tons may be used, preferably greater than on equal to about 20 preferred and greater than or equal to about 35 more preferred.

When injection molding to prepare the substrate of the filtered polymeric composition, a cool time of about 1 to about 35 seconds may be used. Within this range a cool time of greater than or equal to about 5 seconds is preferred, with greater than or equal to about 7 seconds more preferred, and greater than or equal to about 12 seconds even more preferred. Also within this range a cool time of less than or equal to about 25 seconds may be used, with less than or equal to about 20 seconds preferred, and less than or equal to about 15 seconds more preferred.

Futhermore, when injection molding to prepare the substrate from the filtered polymeric composition, a hold pressure of about 1 to about 40 kgf/cm^2 may be used. Within this range a hold pressure of greater than or equal to about 5 kgf/cm^2 is preferred, with greater than or equal to about 10 kgf/cm^2 more preferred, and greater than or equal to about 15 kgf/cm^2 even more preferred. Also within this range a hold pressure of less than or equal to about 35 kgf/cm^2 may be used, with less than or equal to about 30 kgf/cm^2 preferred, and less than or equal to about 25 kgf/cm^2 more preferred.

If the filtered polymeric material is used to form a data storage media substrate, for example, additional processing such as electroplating, coating techniques (spin coating, spray coating, vapor deposition, screen printing, painting, dipping, sputtering, vacuum deposition, electrodeposition, meniscus coating, and the like), lamination, data stamping, embossing, surface polishing, fixturing, and combinations comprising at least one of the foregoing processes, among others conventionally known in the art, may be employed to dispose desired layers on the polymeric material substrate. Essentially, the substrate may optionally be formed, in situ, with the desired surface features disposed thereon on one or both sides, a data storage layer such as a magneto-optic material also on one or both sides, and an optional protective, dielectric, and/or reflective layers. The substrate can have a substantially homogenous, tapered, concave, or convex geometry, with various types and geometries of reinforcement optionally employed to increase stiffness without adversely effecting surface integrity and smoothness.

An example of a polymeric material storage media comprises an injection molded filtered polymeric material substrate that may optionally comprise a hollow (bubbles, cavity, and the like) or filled (metal, plastics, glass, ceramic, etc., in various forms such as fibers, spheres, etc.) core. Disposed on the substrate are various layers including: a data layer, dielectric layer(s), a reflective layer, and/or a protective layer. These layers comprise conventional materials and are disposed in accordance with the type of media produced. For example, for a first surface media, the layers may be protective layer, dielectric layer, data storage layer, dielectric layer, and then the reflective layer disposed in contact with the substrate. A preferred data storage media that may be prepared from the polymeric material described herein is disclosed in Application Serial No. 10/648609 entitled "SUBSTRATE AND STORAGE MEDIA FOR DATA PREPARED THEREFROM" filed August 26, 2003 and copending with the present application.

In one embodiment, the storage media comprises a substrate layer, preferably having a thickness of 1.1 mm, made from a filtered polymeric composition prepared by any one of the methods presented herein. The storage media further contains data set adjacent to the substrate layer and a cover layer set adjacent to the data and opposite to substrate layer to assemble a structure of substrate layer – data – cover layer, although addition layers, e.g., reflective layer and adhesive layer, may be placed in between the sequence of this structure. The cover layer has a thickness of 100 micrometers or less through which a light source passes to read, write, or read and write the data. The foregoing is often referred to as a "single layer disc." In another preferred embodiment, the substrate layer of a storage media is made from the filtered polymeric materials prepared by any one of the methods presented herein and preferably has a thickness of 1.1 mm and further contains a first recording layer set adjacent to the substrate layer followed by a spacer layer of 25 micrometers thickness, a second recording layer, and a cover layer having a thickness of 75 micrometers through which the light source passes to read, write, or read and write data to the recording layers. The foregoing arrangement of layers is often referred to as a "dual layer disc." In all instances, it is important that the cover layer have a high accuracy for the desired thickness, high transmittance of the laser light, e.g., 405 nm, and low

birefringence. Additionally, for storage media that will not be contained within a protective case, the cover layer needs to provide scratch resistance and finger print resistance. Consequently, in many instances the cover layer will contain multiple layers that in combination have the desired thickness. For example, a desired 100 micrometer "cover layer" may contain a 98 micrometer actual cover layer with a 2 micrometer hard coat layer to achieve the desired scratch- and fingerprint-resistances.

The actual layer compositions between the substrate layer made from the filtered polymeric materials prepared by any one of the methods presented herein, and the cover layer can vary widely depending on the format-type of the storage media. For example, different layers are utilized for read-only media, write-once media, and rewritable media as well as for single layer and dual layer media and various light wavelengths and objective-lens numerical apertures. It is contemplated that the filtered polymeric materials prepared by any one of the methods presented herein will have utility as the substrate layer of a storage media regardless of the ancillary layers utilized.

It should be clear that the present invention includes a poly(arylene ether)/poly(alkenyl aromatic) composition having, on average, less that 1 particulate, preferably less that 0.5 particulate, and more preferably no particulates, of 175 micrometer, preferably 140 micrometer, more preferably 100 micrometer, average diameter per gram of the composition and a method to prepare such composition. It should also be clear that the present invention includes a poly(arylene ether)/poly(alkenyl aromatic) composition having on average less than 10 particulates, preferably less that 5 particulates, and more preferably less than 3 particulates, of 50 micrometer average diameter per gram of the composition and a method to prepare such composition. It should be clear that the present invention includes a poly(arylene ether)/poly(alkenyl aromatic) composition having on average less than 10 particulates, preferably less than 5 particulates, preferably less than 3 particulates, of 40 micrometer average diameter per gram of the composition and a method to prepare such composition. It should also be clear that the present invention includes a poly(arylene ether)/poly(alkenyl aromatic) composition having on average less than 30 particulates, preferably less than 20 particulates, more preferably less than 10, and

yet more preferably less than 5 particulates, of 30 micrometer average diameter per gram of the composition and a method to prepare such composition. Further, it should be clear that the present invention includes a poly(arylene ether)/poly(alkenyl aromatic) composition having on average less than 200 particulates, preferably less than 50 particulates, more preferably less than 40 particulates, and yet more preferably less than 25 particulates, of 20 micrometer average diameter per gram of the composition and a method to prepare such composition. It should be clear that the present invention includes a poly(arylene ether)/poly(alkenyl aromatic) composition having less than 60 particulates, preferably less than 50 particulates, more preferably less than 40 particulates, within the range of 20 to 100 micrometer average diameter per fifteen gram of the composition and a method to prepare such composition. The aforementioned particle diameters are based on an average of five measurements made on each sample, i.e. five sample measurements.

The present invention also includes a data storage medium having a substrate layer comprising a filtered polymeric composition containing poly(arylene ether) resin and poly(alkenyl aromatic) resin as provided herein; wherein the substrate layer has less than fifty particulates having average particle diameters within the range of 20 to 100 micrometers, more specifically within the range of 30 to 100 micrometers. In a preferred embodiment, the aforementioned substrate additionally contains no particulates having average particle diameters larger than 175 micrometers, more specifically no particles having average particle diameters larger than 100 micrometers.

In one embodiment, a method of purifying a polymeric composition, comprises melt blending poly(arylene ether) and poly(alkenyl aromatic) in an extruder to form a melt; and melt filtering the melt through a melt filtration system to produce a filtered polymeric composition; wherein the filtered polymeric composition has, based on an average of five sample measurements, at least one of: (a) less than 200 particulates having an average diameter of 20 micrometers per gram of the filtered polymeric material, (b) less than 30 particulates having an average diameter of 30 micrometers per gram of the filtered polymeric material, (c) less than 5 particulates having an average diameter of 50 micrometers per gram of the filtered polymeric material, (d)

less than 50 particulates within the range of 20 to 100 micrometers average diameter per fifteen grams of the filtered polymeric material, and (e) zero particulates having an average diameter of at least 175 micrometers per gram of the filtered polymeric material. The method further comprises at least one of (a) pelletizing the filtered polymeric composition, (b) filtering a solution comprising solvent and poly(arylene ether) through a solution filtration system to form a filtrate, removing solvent from the filtrate to form a concentrate comprising the poly(arylene ether), (c) operating the extruder at a specific throughput rate of about 0.5 kg/cm^3 to about 8 kg/cm^3, wherein the extruder is a twin-screw extruder, (d) operating the melt filtering wherein the melt has an average residence time in the extruder of less than or equal to about 1 minute, (e) melt blending the melt with an additive selected from the group consisting of flame retardants, mold release agents, lubricants, antioxidants, thermal stabilizers, ultraviolet stabilizers, pigments, dyes, colorants, anti-static agents, conductive agents, and combinations comprising at least one of the foregoing additives, (f) melt blending the melt with an impact modifier, (g) locating the melt filtration system at the die head of the extruder, (h) blanketing of the internal free space of the extruder with an inert gas, (i) using a melt pump, (j) melt filtering under conditions wherein less than a five-fold pressure drop is observed as compared to the initial pressure drop obtained with a clean filtration system, (k) using an in-line or off-line quality monitoring system, (l) cooling the melt with de-ionized filtered water, (m) melt filtering the melt in a Class 100 environment, (n) packaging the filtered polymeric composition in a Class 100 environment, (o) wherein the melt filtration system comprises a by-pass system, and (p) pelletizing the filtered polymeric composition with an underwater die-face pelletizer system or a water ring pelletizer system.

In one embodiment, a data storage medium comprises a substrate layer, data and a cover layer, wherein the data is located between the substrate layer and the cover layer, wherein the cover layer has a thickness of 100 micrometers or less through which a light source passes to read, write, or read and write the data; wherein the substrate layer comprises a filtered polymeric composition; wherein the filtered polymeric composition comprises about 90 to about 10 percent by weight of poly(arylene ether) resin and about 10 to about 90 percent by weight of poly(alkenyl

aromatic) resin and wherein the filtered polymeric composition has, based on an average of five sample measurements, at least one of: (a) less than 200 particulates having an average diameter of 20 micrometers per gram of the filtered polymeric material, (b) less than 30 particulates having an average diameter of 30 micrometers per gram of the filtered polymeric material, (c) less than 5 particulates having an average diameter of 50 micrometers per gram of the filtered polymeric material, (d) less than 50 particulates within the range of 20 to 100 micrometers average diameter per fifteen grams of the filtered polymeric material, and zero particulates having an average diameter of at least 175 micrometers per gram of the filtered polymeric material.

All cited patents, patent applications, and other references are incorporated herein by reference in their entirety. The invention is further illustrated by the following non-limiting examples.

EXAMPLES

Four example runs (Example runs 1-4) were performed to illustrate the method of melt filtering a melt comprising polyphenylene ether and polystyrene to form a polymeric material having reduced levels of particulate impurities.

Example run 1: A 40/60 percent by weight blend of polyphenylene ether (PPE, powder, 0.33 IV available from GE Advanced Materials, Plastics) and polystyrene (xPS, Novacor 2272; Mw 214,000, Mn 71,600, Mw/Mn 2.99; available from Nova Chemical) was compounded in a 40 millimeter (mm) twin screw compounder equipped with a vacuum vent. A vacuum was applied to the vent at about 20 inches of mercury (508 millimeters of Hg). The compounded material was fed to a single screw extruder equipped with 3 barrels (zones). The extruder was equipped with a sintered metal fiber filter (PALL, 3 micrometer pores, candle geometry) located at the extruder die head.

The extruded melt strands were run through a clean, filtered water bath, the water having been filtered through a 10 micrometer filter to remove rust and impurities. The cooled strands of extruded polymeric material were dried and pelletized. Batches

of the extruded melt were collected throughout the run, about every half hour. The extruder processing conditions are provided in Table 1.

The procedure of Example run 1 was repeated for Example run 2 except that a 30 mm twin screw extruder was employed. The extruder processing conditions for Example run 2 are also provided in Table 1.

The procedure of Example run 1 was repeated for Example runs 3 and 4. The PPE-xPS formulation for Example runs 3 and 4 was a 50/50 percent by weight blend of 0.33 IV PPE and EB3300 grade xPS (Mw 276,000, Mn 51,500, Mw/Mn 5.36; available from Chevron Phillips Chemical). A 40 mm twin-screw extruder was used for Example run 3, while a 30 mm twin-screw extruder was used for Example run 4. The processing conditions for Example runs 3 and 4 are provided in Table 1. For all of the Examples the drive, rate, pressure, and melt temperature are averaged for the entire run.

Table 1.

Example	**1**	**2**	**3**	**4**
Zone 1 (°C)	232	232	232	232
Zone 2 (°C)	260	260	260	260
Zone 3 (°C)	277	277	277	277
Filter 1 (°C)	277	277	277	277
Filter 2 (°C)	277	277	277	277
Die (°C)	277	277	277	277
Screw (rpm)	85	100	85	85
Drive (amps)	8.0	7.4	10.0	11.0
Rate (kg/hr)	6.1	6.9	7.0	6.8
Filter In Press. (kg/cm^2)	198	227	201	275
Filter Out Press. (kg/cm^2)	26	14	25	27
Filter In Melt Temp. (°C)	278	318	279	281
Filter Out Melt Temp. (°C)	292	298	296	296
Visible Specks (avg.)	3.3	2	1.6	1.7
Filter Type/pore size (micrometer)	PALL candle, 3	PALL candle, 3	PALL candle, 3	PALL candle, 3

[0100] Samples from the runs of Examples 1-4 were tested for visual particulates according to the following procedure. Samples of polymeric material for each run were taken about every half hour for each of the Example runs (1-4). Each sample was tested twice for visible particulates. Particles of 30 micrometer average diameter or greater are readily observed without magnification. Two ounce sample bottles with polyseal caps were subjected to a stream of filtered air to remove any particulates present. The bottles were rinsed with a small amount of HPLC grade chloroform ($CHCl_3$) and fifty milliliters (ml) of HPLC grade $CHCl_3$ was added to each sample bottle. Using a lightbox, the number of visible specks or particulates was recorded for each $CHCl_3$ blank. A 10.00 gram amount of a sample was weighed out on a clean aluminum pan and added to one of the bottles containing $CHCl_3$. This procedure was repeated for every sample. The samples were allowed to dissolve and then viewed in the lightbox for the presence of visible specks. An average number of specks were calculated for each run, four runs total (Examples 1-4). The results of the visible particle analysis for Example runs 1-4 are found in Table 1. Typical visible speck numbers for similar compositions prepared without the use of the melt filter are in excess of 50 for a 10 gram sample. These data are quite unexpected as with the relatively large number of specks in the unfiltered material, it was expected that the small pore size filter as used in these examples would plug rapidly. Additionally, it was expected that gelled particles would distort and pass through the filter leading to a significantly higher particulate number. For comparative purposes, a 500 mesh woven metal screen filter having pore openings of 25 micrometers afforded filtered material having in excess of 10 visible specks, i.e. specks greater than 30 micrometers, per 10 gram sample. It should be clear that one embodiment of the present invention is a method to make a composition comprising poly(arylene ether) and poly(alkyenyl aromatic) that has less that 20 visible specks, preferably less than 10 visible specks, more preferably less than 5 visible specks, per 10 gram sample.

Several samples from the runs of Examples 1 – 4 were additionally analyzed to obtain a size distribution of the particulate contaminants present in the materials. Two samples from Example run 2 (Ex. 2, S1 and Ex. 2, S2), one sample from Example run 3 (Ex. 3, S1), and two samples from Example run 4 (Ex. 4, S1 and Ex. 4, S2) were

tested for particulate content according to the procedure below. Amounts of particulates having sizes ranging from 5 micrometers to 100 micrometers were determined using a Pacific Instruments ABS2 analyzer that employs a laser light scattering technique. A 40.0 gram amount of each sample was dissolved in 400 ml of HPLC grade $CHC1_3$ contained in a clean polyethylene bottle. A 20 ml quantity of each sample solution was allowed to flow through the ABS2 analyzer detector at a flow rate of 1 ml/minute (+/- 5%). The amount of particulates of varying sizes present in the sample was measured in the detector during this process. Each sample was tested five times and averaged to yield a final number. Two comparative examples were prepared and tested. Comparative Example 1 (CE 1) was an unfiltered blend of 50/50 weight percent 0.33 IV PPE/EB3300 grade xPS. Comparative Example 2 (CE 2) was optical quality polycarbonate (OQ-PC, LEXAN® 1050 available from GE Advanced Materials, Plastics). The results of the ABS2 analyzer particle analysis in particles per gram can be found in Table 2, along with the blank data ($CHCl_3$ alone).

Table 2.

Example, Sample #	Particulate Size (micrometers)							
	5	10	15	20	30	40	50	100
	Particles per gram							
Ex. 2, S1	654.3	111	38.7	23.3	3.2	0.9	1.2	0.1
Ex. 2, S2	561.8	91.1	34.4	16.5	1.9	0.4	0.6	0.1
Ex. 3, S1	689.8	90	32.7	15.6	2.6	0.5	0.4	0.1
Ex. 4, S1	1919.9	143.7	44.3	20.1	2.4	0.6	0.2	0
Ex. 4, S2	1117.5	114.8	42.9	26.6	3.6	1.8	0.2	0
CE 1	6901.25	1237.5	500	396.25	85	23.75	30	5
CE 2	317.000	58.88	52.88	14.88	3.38	0.75	0	0
$CHCl_3$	15.15	3.65	1.25	0.25	0	0	0	0

The results of the above experiments show a significant reduction in the overall number particulate impurities between the unfiltered sample (CE 1) and the filtered samples (Ex. 2, S1; Ex. 2, S2; Ex. 3, S1; Ex. 4, S1; and Ex. 4, S2). Furthermore, the particulate impurity level of the Examples of the present method is comparable to or better than OQ-PC (CE 2) with regard to particulates of 15 micrometers or greater. It is quite unexpected that such a large reduction in the number of particles per gram in a poly(arylene ether)/poly(alkenyl aromatic) composition was obtained over the particle size range between 20 and 100 micrometers through the use of a sintered metal fiber filter. As previously explained, it was expected that the poly(arylene ether)/poly(alkenyl aromatic) composition would foul or plug the filter rapidly and either push larger particles through the filter or collapse the filter. In contrast, the

procedure of Example run 1 using a 40 mm twin screw extruder was repeated with a run time using the same melt filtration system in excess of 40 continuous hours with less than a 10% increase in the back pressure as measured at a location immediately before the melt filtration system and unexpectedly, without a significant increase in the number of particulates observed in the filtered polymeric composition even after 40 hours of continuous operation. It was additionally expected that the poly(arylene ether)/poly(alkenyl aromatic) composition would have to be run only at a very low specific throughput rate. However, in contrast, specific throughput rates in excess of 5 kg/hr/cm^3 were unexpectedly achieved.

While the invention has been described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

CLAIMS:

1. A filtered polymeric composition, wherein the filtered polymeric composition comprises about 90 to about 10 percent by weight of poly(arylene ether) resin and about 10 to about 90 percent by weight of poly(alkenyl aromatic) resin, and

wherein the filtered polymeric composition has, based on an average of five sample measurements, at least one of:

(a) less than 200 particulates having an average diameter of 20 micrometers per gram of the filtered polymeric material,

(b) less than 30 particulates having an average diameter of 30 micrometers per gram of the filtered polymeric material,

(c) less than 5 particulates having an average diameter of 50 micrometers per gram of the filtered polymeric material,

(d) less than 50 particulates having an average diameter within the range of 20 to 100 micrometers per fifteen grams of the filtered polymeric material, and

(e) zero particulates having an average diameter of at least 175 micrometers per gram of the filtered polymeric material.

2. The filtered polymeric composition of claim 1, wherein the poly(arylene ether) comprises at least one of (a) poly(2,6-dimethyl-1,4-phenylene ether) and (b) poly(2,6-dimethylphenylene ether-co-2,3,6-trimethylphenylene ether), and wherein the poly(arylene ether) has an intrinsic viscosity of about 0.10 to about 0.60 deciliters per gram as measured in chloroform at 25°C; and wherein the poly(alkenyl aromatic) is at least one of (i) atactic homopolystyrene and (ii) non-elastomeric block copolymer of styrene and one or more polyolefins.

3. A method of purifying a polymeric composition, comprising:

melt blending poly(arylene ether) and poly(alkenyl aromatic) in an extruder to form a melt; and

melt filtering the melt through a melt filtration system to produce a filtered polymeric composition;

wherein the filtered polymeric composition has, based on an average of five sample measurements, at least one of:

(a) less than 200 particulates having an average diameter of 20 micrometers per gram of the filtered polymeric material,

(b) less than 30 particulates having an average diameter of 30 micrometers per gram of the filtered polymeric material,

(c) less than 5 particulates having an average diameter of 50 micrometers per gram of the filtered polymeric material,

(d) less than 50 particulates having an average diameter within the range of 20 to 100 micrometers per fifteen grams of the filtered polymeric material, and

(e) zero particulates having an average diameter of at least 175 micrometers per gram of the filtered polymeric material.

4. The method of claim 3, further comprising at least one of:

(a) pelletizing the filtered polymeric composition,

(b) filtering a solution comprising solvent and poly(arylene ether) through a solution filtration system to form a filtrate, removing solvent from the filtrate to form a concentrate comprising the poly(arylene ether),

(c) operating the extruder at a specific throughput rate of about 0.5 kg/cm^3 to about 8 kg/cm^3, wherein the extruder is a twin-screw extruder,

(d) operating the melt filtering wherein the melt has an average residence time in the extruder of less than or equal to about 1 minute,

(e) melt blending the melt with an additive selected from the group consisting of flame retardants, mold release agents, lubricants, antioxidants, thermal stabilizers, ultraviolet stabilizers, pigments, dyes, colorants, anti-static agents, conductive agents, and combinations comprising at least one of the foregoing additives,

(f) melt blending the melt with an impact modifier,

(g) locating the melt filtration system at the die head of the extruder,

(h) blanketing of the internal free space of the extruder with an inert gas,

(i) using a melt pump,

(j) melt filtering under conditions wherein less than a five-fold pressure drop is observed as compared to the initial pressure drop obtained with a clean melt filtration system,

(k) using an in-line or off-line quality monitoring system,

(l) cooling the melt with de-ionized filtered water,

(m) melt filtering the melt in a Class 100 environment,

(n) packaging the filtered polymeric composition in a Class 100 environment,

(o) wherein the melt filtration system comprises a by-pass system, and

(p) pelletizing the filtered polymeric composition with an underwater die-face pelletizer system or a water ring pelletizer system.

5. The method of claims 3 or 4, wherein the melt filtration system comprises a sintered-metal filter, a metal mesh filter, a fiber metal felt filter, a ceramic filter, or a combination comprising at least one of the foregoing filters, and wherein the melt filtration system comprises a filter having a pore size of about 1.0 to about 50 micrometers.

6. A method of purifying a polymeric material, comprising:

melt blending about 60 to about 30 weight percent of poly(arylene ether) and about 40 to about 70 weight percent of polystyrene based on the total weight of poly(arylene ether) and polystyrene in an extruder to form a melt; and

melt filtering the melt through a melt filtration system to produce a filtered polymeric material, wherein the filtered polymeric material is substantially free of visible particulate impurities, and

wherein the melt has a residence time in the extruder of less than or equal to about 1 minute.

7. The method of any of the proceeding claims 3 to 6, wherein the poly(arylene ether) comprises at least one of (a) poly(2,6-dimethyl-1,4-phenylene ether) and (b) poly(2,6-dimethylphenylene ether-co-2,3,6-trimethylphenylene ether), and wherein the poly(arylene ether) has an intrinsic viscosity of about 0.10 to about 0.60 deciliters per gram as measured in chloroform at 25°C; and wherein the poly(alkenyl aromatic) is at least one of (i) atactic homopolystyrene and (ii) non-elastomeric block copolymer of styrene and one or more polyolefins.

8. An article comprising the filtered polymeric composition of claims 1 or 2, wherein the article is formed by injection molding, blow molding, extrusion, sheet extrusion, film extrusion, profile extrusion, pultrusion, compression molding, thermoforming, pressure forming, hydroforming, or vacuum forming.

9. A data storage medium comprising a substrate layer, data and a cover layer,

wherein the data is located between the substrate layer and the cover layer,

wherein the cover layer has a thickness of 100 micrometers or less through which a light source passes to read, write, or read and write the data;

wherein the substrate layer comprises a filtered polymeric composition;

wherein the filtered polymeric composition comprises about 90 to about 10 percent by weight of poly(arylene ether) resin and about 10 to about 90 percent by weight of poly(alkenyl aromatic) resin and

wherein the substrate layer has less than fifty particulates having average particle diameters within the range of 30 to 100 micrometers.

10. A data storage medium comprising a substrate layer, data and a cover layer,

wherein the data is located between the substrate layer and the cover layer,

wherein the cover layer has a thickness of 100 micrometers or less through which a light source passes to read, write, or read and write the data;

wherein the substrate layer comprises a filtered polymeric composition;

wherein the filtered polymeric composition comprises about 90 to about 10 percent by weight of poly(arylene ether) resin and about 10 to about 90 percent by weight of poly(alkenyl aromatic) resin and

wherein the filtered polymeric composition has, based on an average of five sample measurements, at least one of:

(a) less than 200 particulates having an average diameter of 20 micrometers per gram of the filtered polymeric material,

(b) less than 30 particulates having an average diameter of 30 micrometers per gram of the filtered polymeric material,

(c) less than 5 particulates having an average diameter of 50 micrometers per gram of the filtered polymeric material,

(d) less than 50 particulates within the range of 20 to 100 micrometers average diameter per fifteen grams of the filtered polymeric material, and

(e) zero particulates having an average diameter of at least 175 micrometers per gram of the filtered polymeric material.

11. The data storage medium of claims 9 or 10, wherein the substrate layer contains no particulates having average particle diameters larger than 175 micrometers; and wherein the poly(arylene ether) comprises at least one of (a) poly(2,6-dimethyl-1,4-phenylene ether) and (b) poly(2,6-dimethylphenylene ether-co-2,3,6-trimethylphenylene ether), and wherein the poly(arylene ether) has an intrinsic viscosity of about 0.10 to about 0.60 deciliters per gram as measured in chloroform at 25°C; and wherein the poly(alkenyl aromatic) is at least one of (i) atactic homopolystyrene and (ii) non-elastomeric block copolymer of styrene and one or more polyolefins.