

**METHOD AND SYSTEM FOR MARKING, TRACKING, GRADING AND
CERTIFYING PLASTICS FOR ENABLING STANDARDIZATION AND
TOKENIZATION**

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FIELD OF THE DISCLOSED TECHNIQUE

The disclosed technique relates to the supply chain of plastics, in general, and to methods and systems for increasing the lifecycle of plastics
10 within its supply chain, in particular.

BACKGROUND OF THE DISCLOSED TECHNIQUE

Growing global interest in the welfare of the environment demands minimizing the use of virgin materials, increasing the use of
15 recycled materials and reducing the amount of waste product from materials that are either incinerated or buried in landfills. Many products are capable of being recycled including electronic products, glass, paper, metal, plastics and so on. Such products are referred to hereinafter as “recyclable products” or “recycled products”. At times, recyclable products
20 can be reused as base materials for creating new products and thus can be referred to as “recycled materials”, whereas “virgin materials” refer to raw materials made into first time use products. Recycling is an important aspect of natural resource management and sustainability. A circular

recycling economy, implemented in recent years, expands the lifecycle of the recyclable products via recycling, redistributing and/or re-manufacturing loops along a respective supply chain. Recyclable products may be recycled numerous times in various forms until the recycled materials are
5 no longer useable and must be disposed of. It is thus desired to reduce the amount of disposed waste material by increasing the lifecycle of recyclable products. This further implies that less virgin materials are used in producing products leading to a more sustainable environment and increased health benefits for mankind and Earth's ecosystem.

10 Among significant challenges of the circular recycling economy is the recycling of plastic products. Experts estimate that demand for plastics has increased twentyfold in the past 50 years and that it will double again in the next 20 years. The variety of different types of plastic increases the recycling problem since the recycling processes (chemical and/or
15 mechanical) in many cases are designed according to the specific polymeric materials forming the plastics. To be recycled properly and effectively, plastic products need to be analyzed and sorted accordingly, a process which can be expensive and time consuming. Besides the challenge of sorting plastics appropriately such that their recycling lifetime
20 can be increased, the production of plastics is a complex process involving many industry players from the mining of raw materials and the chemical processing involved in making plastic polymers to the actual creation of plastics products. Properly being able to mark and accurately track plastics

along each step of its production, use, recycling and disposal marks one of the main challenges in successfully implementing a circular recycling economy for plastics. Currently, the limit of most plastics regarding their lifecycle is going from raw material production to consumption and then
5 disposal without being circularly reinserted into the plastics supply chain. Whereas plastics are recycled, most recycled plastics are not fully integrated back into the plastics supply chain and many times, after consumption, collected and sorted plastics are merely put into landfills.

An effective recycling economy requires efficient management
10 along a supply chain, including marking, identifying and tracing virgin as well as recyclable materials. Whereas the problems of recycling management in general and managing plastic recycling, in particular, have been recognized in the conventional art and various systems have been developed to provide a solution, a comprehensive solution which
15 substantially eliminates human error while also incentivizing industry players to participate in the recycling economy of plastics is still lacking.

SUMMARY OF THE PRESENT DISCLOSED TECHNIQUE

It is an object of the disclosed technique to provide a novel
20 method and system for marking, tracking, grading and certifying plastics for enabling standardization and tokenization of plastic materials. In accordance with the disclosed technique, there is thus provided a method for characterizing a plastic material, including the procedures of marking a

plastic material using a chemical-based marker and recording the information in an exchange platform. The marker includes information related to at least one of an ownership of the plastic material, a polymer type of the plastic material, an intended use of the plastic material, a loop count denoting a number of times the plastic material has been recycled, and a percentage of recycled content in the plastic material. The recording enables increased tracking and utilization of the plastic material.

In accordance with another aspect of the disclosed technique, there is thus provided a method for categorizing a most suitable use of a recycled plastic material, including the procedures of recording information about the recycled plastic material in a distributed ledger and inputting the information in an AI-driven algorithm. The information including at least one of a polymer type of the recycled plastic material, an intended use of the recycled plastic material, a loop count denoting a number of times the recycled plastic material has been recycled, and a percentage of recycled content in the recycled plastic material. The AI-driven algorithm can determine the most suitable use for the recycled plastic material based on the information, thereby enabling optimal and efficient allocation of the recycled plastic material for sustainability benefits.

In accordance with a further aspect of the disclosed technique, there is thus provided a method for determining a standard value of a plastic material, wherein the plastic material is marked by a chemical-based marker, taking into account a determination of at least one externality in at

least one stage in a plastic supply chain. The method includes the procedures of determining a market value of a predetermined quantity of the plastic material, determining the externality in at least one stage in the plastic supply chain, assigning a negative market value to the externality, and producing the standard value of the plastic material using the market value and the negative market value. The negative market value reflects costs associated with environmental impacts and sustainability.

In accordance with another aspect of the disclosed technique, there is thus provided a method for sorting a plastic material, including the procedures of recording information about the plastic material in a distributed ledger and inputting the information in an AI-driven algorithm. The information including at least one of a polymer type of the plastic material, an intended use of the plastic material, a loop count denoting a number of times the plastic material has been recycled, and a percentage of recycled content in the plastic material. The AI-driven algorithm can determine if the plastic material can be recycled for the intended use of the plastic material. The AI-driven algorithm can determine a new application of the plastic material if the plastic material is determined to have finished a lifecycle in the intended use of the plastic material, thereby enhancing a sustainability of the plastic material and reducing waste.

In accordance with a further aspect of the disclosed technique, there is thus provided a method for grading a plastic material, including the procedures of marking a plastic material using a chemical-based marker

and recording the information in an exchange platform. The marker includes information related to at least one of an ownership of the plastic material, a polymer type of the plastic material, an intended use of the plastic material, a loop count denoting a number of times the plastic material
5 has been recycled, and a percentage of recycled content in the plastic material. The recording enables increased tracking and utilization of the plastic material throughout a lifecycle of the plastic material. The recording in a recycled stage of the plastic material is used to assign a grade to the plastic material, wherein the grade is homogeneous based on the
10 chemical-based marker. The grade can be used to certify the plastic material.

BRIEF DESCRIPTION OF THE DRAWINGS

The disclosed technique will be understood and appreciated more fully from the following detailed description taken in conjunction with the drawings in which:

5 Figure 1 is a schematic illustration of the circular economy, according to an embodiment of the disclosed technique;

Figure 2 is a schematic illustration of the circular economy as applied to the plastic supply chain, according to another embodiment of the disclosed technique;

10 Figure 3 is a schematic illustration showing a marking and tracking system for plastics within the lifecycle of plastics, constructed and operative according to a further embodiment of the disclosed technique;

Figure 4 is a schematic illustration showing the integration of the marking and tracking system for plastics of Figure 3, constructed and
15 operative according to another embodiment of the disclosed technique;

Figure 5 is a schematic illustration showing the marking and tracking system for plastics wherein tokenization is possible, constructed and operative according to a further embodiment of the disclosed technique;

20 Figures 6A and 6B are schematic illustrations of a marking and tracking system for plastics according to respectively a flexible loop construction and a rigid loop construction, constructed and operative according to another embodiment of the disclosed technique; and

Figure 7 is another schematic illustration showing the marking and tracking system for plastics wherein grading and certification is shown leading to tokenization, constructed and operative according to a further embodiment of the disclosed technique.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The disclosed technique overcomes the disadvantages of the prior art by providing a novel system and method for marking, tracking, grading and certifying plastics throughout the plastic supply chain from the extraction of raw materials until plastic products are either recycled or disposed of. The tracking and grading of plastics according to the disclosed technique enables enhanced sorting and categorizing of plastic products for recycling and reinsertion into the plastic supply chain. The novel system and method can be used to create a digital platform wherein the physical marking of a plastic material is unified with the entire plastic supply chain from virgin material, to plastic product, to recycled material to eventually disposal. The physical marking is thus present throughout the entire plastic ecosystem and enables a standardization for plastics regarding its grade and composition. The digital platform also enables a tokenization of plastics, thereby enabling a trade conversion wherein a given quantity of physical plastic can be translated into a tradeable and monitored commodity. The disclosed technique also provides for a system and method which are substantially removed from human error thus ensuring high reliability of data regarding marked, tracked and graded plastics. This ensures that an authenticated certificate of the grade of a plastic can be issued, thereby improving the efficiency in which recycled plastics can be reinserted into the plastic supply chain. The data regarding a plastic material can be used to record the number of times a plastic material has

been recycled, the composition of a plastic product regarding its virgin materials and recycled materials, as well as being provided as input for an artificial intelligence (herein abbreviated **AI**) algorithm that can determine a most appropriate use of a plastic product, thereby enhancing a plastic product's functionality and reusability. According to the disclosed technique, the algorithm can determine the most appropriate process which a used plastic product should undergo, based on the plastic product's previous uses and number of times it has been recycled. This can include converting the plastic product to a different type of manufactured plastic product, repurposing the plastic product or deciding that the plastic product should be disposed of. The disclosed technique further relates to a novel system and method for certifying and then tokenizing a plastic product, thus enabling a plastic product to be assessed for its grade and composition and then assigned an economic value, wherein the economic value can also reflect a negative value, thus representing the cost to society (for example, environmental costs, health-related costs and the like) of producing plastic and/or the costs associated with recycling and collecting plastics. The economic value is determined based on a number of factors including the composition of the plastic material, the amount of virgin versus recycled material used in making the plastic product as well as financial levies and incentives related to industry players in the plastic supply chain. According to the disclosed technique, the economic value and tokenization can be used to create an exchange market wherein tokens and credits for plastics

can be assigned, used and traded within the plastic supply chain, with credits having real monetary value. As mentioned, the economic value can factor in negative values as well.

According to the disclosed technique, a distributed ledger system
5 is implemented wherein all stages and the products of those stages in the plastic supply chain are marked and tracked. The stages in the plastic supply chain include the following: 1) production, 2) manufacturing, 3) distribution, 4) consumption, 5) recycling and 6) disposal. These stages can be explained as follows:

10 1. Production – this involves extracting raw materials like petroleum and/or natural gas, which are then processed into various plastic resins. A distinction can be made between producers which mine and extract the base materials, such as petrochemicals and chemical feedstocks as opposed to producers which convert the raw materials into
15 plastic pre-cursor materials such as polymers and additives. These latter producers are sometimes referred to as plastic compounders or plastic extruders.

2. Manufacturing – after producing plastic resins or plastic pellets, the pre-cursor materials are made into various products, including
20 packaging materials and consumer goods.

3. Distribution – manufactured plastic products are then distributed through a complex network of suppliers, manufacturers and retailers.

4. Consumption – plastic products are used by consumers in various applications.

5. Recycling – this stage is an essential stage in the plastic supply chain, wherein used plastic materials are collected, sorted, processed and transformed into new products and/or materials. Recycling can include mechanical recycling wherein recycled plastics are used in new products as well as chemical recycling wherein recycled plastics are used in new materials.

6. Disposal – after single use and at times after multiple recycling rounds, plastic products are typically disposed of in landfills, incinerated or disposed of as litter in the environment.

According to the disclosed technique, a chemical marker is added to a plastic material during the production stage and the recycling stage. The chemical marker in the production stage can include data related to the ownership of the material, its specific polymer type and its intended use cases (e.g., packaging or product, electronic product or food storage product, and the like). The chemical marker in the recycling stage can include data related to the ownership of the material, its specific polymer type, its intended use cases, a loop count denoting the number of times it has been recycled and the percentage of recycled content. The chemical marker can also be used to assign a grade to a plastic material in its production stage as well as in its recycling stage. The chemical markers of the disclosed technique are added to the plastic material or plastic product

at the molecular level, thus they retain their encoded information even as the plastic material or plastic product changes form. According to the disclosed technique, the plastic material is scanned for the chemical marker at each stage of the plastic supply chain, thus enabling a plastic material to

5 be tracked. The scanning is performed by a device having a network connection such that the scanned data can be uploaded to a distributed ledger system implemented on a computing platform, as per the disclosed technique. The scanned data is then assembled into a blockchain for the material which allows for further tracking, grading and categorizing of the

10 plastic material as it moves around the plastic supply chain. The scanned data can also be used to track ownership of the plastic material at each stage of its lifecycle within the plastic supply chain. The blockchain thus allows for a comprehensive characterization of a plastic material within its lifecycle. A plastic material can thus be tracked precisely and as explained

15 later on, used for the most appropriate stage of the plastic supply chain, thus fostering responsible and sustainable use of plastics. In addition, by tracking the plastic material through the various stages of its lifecycle, not only can a grade be assigned to the plastic material at the various stages, but once the plastic material has run through an entire lifecycle (i.e., from

20 production to recycling) at least once, a certificate on the recycled material can be issued, either digital or real, thereby enhancing trust in the market and allowing industry players to reinsert the plastic material into the plastic supply chain without worry of fraud and/or compromise on the quality and

composition of the plastic material being reinserted into the plastic supply chain.

Based on the grading as well as the data stored for a given plastic material, according to the disclosed technique, AI-driven algorithms can be used to analyze the data captured and stored in the blockchain of the plastic material. The AI-driven algorithms can be trained to determine the most suitable use cases for the plastic material based on its stored characteristics, such as polymer type, loop count and recycled content. Thus a given plastic may be determined to be best suited for mechanical recycling and repurposing as a packaging material, whereas a packaging material having been recycled three times may be best suited for chemical recycling. This aspect of the disclosed technique ensures optimal and efficient allocation of plastic materials to applications where they can deliver the highest performance and sustainability benefits. It is noted that the input to the AI-driven algorithms is derived from scanned chemical markers which are stored as a blockchain. Thus the data used as input is substantially authenticated with the physical plastic material as opposed to being derived from a secondary source, such as a barcode placed on a plastic material (as is done in the prior art). The latter affords the possibility of human error and abuse whereas the former is substantially removed from such errors as the information is encoded in the plastic material itself. The only possible error in the former, according to the disclosed technique, is if the various scans at each stage of production are missed. It is thus noted that

according to the disclosed technique, the existence of a physical marker (at the molecular level) within the plastic material at all stages of its lifecycle allows for a standardization to be put into effect regarding the quality of a given plastic material. Standardization is substantially only possible when

5 the criteria for judgment and scoring cannot be reasonably tampered with and wherein the parameters for grading are present at all times and not subject to simple human manipulation. The physical marker of the disclosed technique enables this standardization of plastics as the marker is present at all stages of a plastic material's lifecycle and also contains

10 within it a homogeneous set of data regarding the quality of the plastic material with industry relevance (such as the grade of the plastic, its virgin versus new material composition as well as a loop count of how many times the plastic material has been recycled). The standardization of the disclosed technique thus enables a unified way in which the quality of a

15 plastic material can be evaluated, graded and then certified.

According to another aspect of the disclosed technique, a plastic token is developed, exchangeable for plastic credit, wherein a real world value (which can include negative values and costs as well) can be assigned to a given quantity of plastic taking into account the scanned data

20 of plastics as per the aforementioned blockchain. The real world value can be used in an exchange market for turning plastics into a commodity that can be traded, with incentives used to encourage the use of recycled materials and levies used to discourage the use of virgin materials. The

plastic token and credit of the disclosed technique takes into account the market value of a given quantity of plastics (for example, a ton of plastics or five tons of plastics) as well as any externalities associated with the production and use of plastics at a given stage of its lifecycle. Thus the disclosed technique enables a tokenization of plastic materials. As described below, the tokenization can be a function of the lifecycles of a plastic material. Thus for example, each successful round a plastic material goes through is whole lifecycle and is then reinserted into the plastic supply chain may be afforded a token that can be exchanged for credits.

10 The tokenization and value of a plastic material can be determined based not only on the loop count of the plastic material but also the externalities defined for a given stage in the plastic supply chain. Externalities are defined as metrics that take into account the environmental impact of a given stage in the lifecycle of plastics (from mining the raw material to its recycling) and the sustainability of a given stage in the production and use of plastics. By quantifying these factors, a more holistic and accurate representation of the true value of plastics can be determined thereby enabling a more free and less corrupt market of plastics that is substantially unaffected by human factors. It is noted that the plastic token and credit does not just represent a finished plastic product (what is commonly referred to as plastic) but can represent any of the products and/or materials present in the plastic supply chain. Thus plastic tokens can be representative of raw materials and base materials in the process of

making plastics, additives and mixtures used to make plastic pellets and resins as well as recycled plastic materials (either recycled mechanically or chemically). Said otherwise, tokens can be awarded at any stage in the lifecycle of plastics based on the data stored about a plastic material in a
5 given stage while also taking into account the externalities of that given stage.

According to the disclosed technique, externalities can be defined as the unintended and unfavorable side effects of a product and/or process/service that affect third parties who are not directly involved in the
10 production and/or consumption of the product or process/service. These externalities occur when the actions of individuals and/or businesses have a harmful effect on others and in the prior art, the cost of these effects is not reflected in the price of the product and/or process/service. Such terminology is known in general in the context of economics and
15 environmental studies and relates to quantifying the value of the side effects (usually negative) in the production of a product which humanity uses. For example, negative externalities are usually associated with phenomena such as pollution as well as health impacts, both physical and social, on humans and the environment. According to the disclosed technique, the
20 externalities in each stage in the lifecycle of plastics are quantified. Therefore the cost of production of a given stage in plastics is not only a function of the actual labor and material costs involved in that stage of production but also factors in the externalities of each stage, which if

negative (i.e., the usual context of externalities), adds to the cost of production. In addition, according to the disclosed technique, a given stage of production can also have its value modified based on stored data regarding the materials used in the given stage of production, as mentioned
5 in the aforementioned blockchain. Therefore, the value of a given stage of production of plastics can be incentivized and/or levied depending on how sustainable a given stage of production is based on parameters of the given stage of production.

As the plastic supply chain is complex and a far-reaching network,
10 encompassing production, distribution, consumption, recycling, and the disposal of plastic products, the issues of each stage of its production and use must be identified and quantified regarding the specific externalities associated with plastic throughout its supply chain and lifecycle. As per the listing above, the plastic supply chain can be broken down into several key
15 stages, each of which contributes to the creation of externalities, as follows:

1. Production – since this stage involves the extraction of raw materials like petroleum or natural gas, which are then processed into various plastic resins, the externalities of this stage result in energy consumption and as well as environmental impacts.
- 20 2. Manufacturing – after plastic resins are produced, they are made into various products, including packaging materials and consumer goods. The manufacturing processes in creating these products thus generate waste, gaseous and liquid emissions, as well as other harmful

environmental consequences, thus generating further externalities that are specific to this stage of the lifecycle of plastics.

3. Distribution – once plastic products are made and produced, they then need to be distributed through a complex network of suppliers, manufacturers and retailers, which involves transportation and logistics. This leads to externalities such as greenhouse gas emissions, air pollution and traffic congestion.

4. Consumption – not part of the production cycle but certainly part of the lifecycle of plastics is the use of plastic products by consumers in various applications. Externalities in this case include factors such as waste generation, littering and the release of microplastics into the environment.

5. Recycling – today recycling represents an essential stage in the plastic supply chain, wherein used plastic materials are collected, sorted, processed and transformed into new products and/or materials. Recycling processes however can vary widely regarding technology, energy consumption and efficiency, each of which can carry with it context and environment specific externalities.

6. Disposal – when plastics cannot be recycled, or more typically, when consumers do not recycle plastics and merely toss them to the garbage, plastics products typically end up in landfills, being incinerated and/or as litter in the environment. Thus the act of disposing plastics also

carries with it externalities such as the persistence of plastic waste, the leaching of harmful chemicals and potential harm to wildlife.

According to the disclosed technique, each stage in the lifecycle of plastics must be quantified regarding the precise environmental and social consequences of that given stage in the plastic supply chain. This must include the following factors and can be specific given the context, content and location of a given stage in the lifecycle of plastics. These factors include:

1. Widespread impacts – the pervasive reach of plastics extends far beyond its intended purpose, thereby generating a wide array of externalities that ripple across environmental and social spheres. Thus impacts such as environmental pollution on marine ecosystems, terrestrial environments and human health must be factored in, wherein the effects of the pollution may be different for each of those spheres.

2. Interwoven supply chain – the production of plastics involves an intricate network of stakeholders from production to consumption and disposal, thus externalities to specific actors and/or stages must be determined in order to properly value plastics to then assign responsibility and implement effective mitigation strategies.

3. Ripple effects – sometimes externalities can cause repercussions in other, unintended spheres, and thus second-order and higher-order externalities can be factored in as well. Plastics can cause damage to the environment which is immediate and visible. However

by-products of plastics, such as microplastics, subtly infiltrate ecosystems, accumulating over time and causing long-term harm. Measuring and attributing any delayed effects (i.e., higher-order externalities) to specific plastic products should therefore be factored in as well.

5 4. Data obscurity – the state of the art regarding the information readily available about the supply chain of plastics is severely lacking due to the scarcity of data and a lack of transparency within the plastic supply chain. Added to this as well is the lack of standardization within the art of how plastics are graded and categorized. Many industry players shroud
10 any plastic-related data and environmental footprints in secrecy, thereby impeding comprehensive analysis. According to the disclosed technique, such factors can be mitigated as data about a plastic material/product during its lifecycle is molecularly encoded in the plastic material/product itself and stored in a distributed ledger, thereby enabling a more
15 comprehensive analysis of the externalities of each stage in the lifecycle of plastics. In addition, the disclosed technique affords a standard when it comes to plastics regarding its grade and composition, thus simplifying the task of comprehensively analyzing the externalities of each stage in the plastic supply chain.

20 5. Geographic variation – as mentioned above, the environmental and social impacts of plastic are not uniform across the globe and thus externalities and their quantification may be location specific around the world. Geographic factors, such as environmental conditions

and waste management infrastructure, play a significant role in shaping the trajectory of plastic pollution and thus these variations are also taken into account when determining externalities for a given stage of plastic in its lifecycle.

5 According to the disclosed technique, a multi-stage tax mechanism is disclosed, which is possible due to the blockchain data available regarding plastic production, consumption, recycling and disposal. The tax mechanism provides incentives for industry players and actors in the various stages of the lifecycle of plastics who practice sustainable
10 techniques of production and use while penalizing, through the use of levies, those who do not. The mechanism involves the following procedures:

1. Identification – as per the disclosed technique, the specific negative externalities associated with each stage of plastic production and
15 use are defined. Such a stage encompasses various impacts as delineated above, such as pollution (human, environmental, social and the like), resource depletion as well as health hazards.

2. Measurement – the mechanism is tied to a distributed ledger which is coupled with an exchange platform. The exchange platform
20 enables standardized methods to be used to quantify the externalities at each production stage, taking into account factors such as the composition of the plastic material as well as the geographic location where a given stage occurs. The exchange platform can store and thus establish

consistent metrics and data collection processes of each stage in the lifecycle of plastics to assess the environmental and social costs incurred per stage.

3. Valuation – in this part of the mechanism, a monetary value to a measured externality is assigned. For example, the amount of a given pollution caused by a given stage can be monetized based on an assigned budgetary cost a given jurisdiction allocates to minimizing the given type of pollution. By attaching a price tag to the external costs, negative impacts can be internalized and an economic incentive can be provided for reducing externalities (which carry a real-world cost).

4. Taxation – as per the mechanism of the disclosed technique, a tax can be levied at each stage of the lifecycle of plastics based on the calculated externality value at each stage of the plastic supply chain. The tax thus reflects a more comprehensive cost of the product to society, including not only its use but also its environmental impact, thereby creating a financial disincentive for excessive externalities.

5. Pass-through – as per the mechanism of the disclosed technique and the data available in the blockchain about a plastic material at each stage of its lifecycle, the tax cost of the previous step can be split across the various stages in the plastic supply chain, thus ensuring that a more comprehensive product cost is reflected at each stage of production. For example, an externality such as ecosystem pollution due to plastics can be traced back to not only consumption but also distribution, manufacturing

and even production. Each of the aforementioned stages may be taxed differently to reflect this externality, however each stage of the supply chain thus takes part, financially, in the negative externalities due to the mere consumption of a plastic product. This step therefore encourages
5 transparency and motivates all actors along the supply chain to take responsibility for reducing externalities.

6. Reinvestment – as a complement to the previous two steps, tax revenues collected can be allocated to mitigate the effects of a given externality. For example, funds collected as tax revenues can be invested
10 in recycling infrastructure, pollution control measures, and/or research and development of sustainable materials.

7. Transparency – according to the disclosed technique, due to the use of implementation of the tax mechanism as described above on a distributed ledger which is coupled with an exchange platform, reporting for
15 accountability and audit purposes is simplified for all players and actors in the plastic supply chain, thereby enabling accurate calculation and disclosure of externalities at the various stages of the supply chain. Such transparency promotes trust and enables regulators and stakeholders to monitor progress.

20 8. Incentives – also as a complement to previous steps mentioned above, the mechanism of the disclosed technique can be used to offer benefits to industry players and/or actors for reducing or eliminating externalities. Actors that invest in cleaner production methods, sustainable

materials and/or effective waste management techniques can potentially be provided with lower tax liabilities, providing a strong incentive for positive environmental action.

9. Feedback loop – the disclosed technique also enables a
5 periodic review and adjustment of the tax system to ensure that it remains effective, thereby factoring in better quantifications of various externalities as technology evolves and new information and/or challenges emerge.

According to the disclosed technique, a plastic credit can be generated wherein a given quantity of plastics can be assigned a value and
10 represented as a token that can be traded. Within the plastic supply chain, plastic credit incentives can be given by awarding tokens to players who support and use sustainable processes (for example, when raw material producers use recycled materials instead of virgin materials in production) whereas plastic credit penalties can be implemented by increased the costs
15 of tokens for a given stage in the plastic supply chain. Thus stakeholders in a trading platform having plastic credits can use the externality model of the disclosed technique for efficient exchange of externality-related assets, incentivizing reductions and enabling actors to optimize compliance costs while mitigating environmental impacts. The trading platform may enable
20 inclusive stakeholder engagement, thereby allowing for flexible stakeholder addition and providing a transparent interaction mechanism. According to the disclosed technique, this is enabled by granting all stakeholders access to the exchange platform, thus all actors in the plastic supply chain are

represented, wherein stakeholders can also be third parties not directly related to the plastic supply chain, such as NGOs and financial investors. The exchange platform is also adaptable, thus allowing for the addition of different types of stakeholders. As the market of plastics evolves and new
5 players enter, they can be easily integrated into the platform. As mentioned above, the exchange platform also enables costs and incentives to be passed through different stages of the plastic supply chain to all involved parties. This builds trust as well as fostering stakeholder collaboration.

According to another aspect of the disclosed technique, the
10 information collected regarding the various stages of the plastic supply chain stored as a blockchain in the distributed ledger can be used for enhanced marking, tracking and sorting of a plastic material. Thus the initial characterization of a plastic material along with additional information added to the exchange platform can be inputted to an AI-driven algorithm
15 for efficiently redirecting and repurposing a plastic product for new uses once the plastic product has completed its lifecycle in a different application. Thus a plastic material which has been recycled twice as a consumer product may be characterized to be recycled in its third loop as a packaging product, thus enhancing the plastic material's sustainability and reducing
20 waste.

Reference is now made to Figure 1, which is a schematic illustration of the circular economy, generally referenced 100, according to an embodiment of the disclosed technique. As shown, the circular economy

represents the continued reuse of a material from design 102 to recycling 112. Once a given material exists, it can be designed 102 into a product, produced, manufactured and/or remanufactured 104 as a product, distributed 106, consumed 108, collected 110 and then recycled 112 before
5 starting the cycle all over again. As shown, consumption of a product can include its use, its repair and/or its reuse as another product. So long as a product remains within circular economy 100, outside resources 114, such as raw materials, do not need to be tapped to design, produce and use in further products.

10 Shown as well are two external points to the circular economy, an inlet point 114 regarding raw materials and base material production as well as an outlet point 116 regarding residual waste and disposal. Many products in the world are first produced from raw materials which are made into base materials which can then be used to design products for human
15 consumption. For example, trees and basic wood pre-cursors such as 2x4s, plywood sheets and the like, represent raw materials as well as base materials from which wooden products can be then designed, produced, distributed, used, collected and recycled. Limiting the amount of raw materials that need to be inputted into the circular economy preserves
20 natural resources that are either limited in quantity (such as natural gases and metals) or require extensive periods to replenish (such as trees). Therefore even though raw materials are necessary for the production of many products used in the world, the desire for a more sustainable

environment and world is to reduce the use of raw materials in general in the production of human goods and products. Outlet point 116 represents the point in the circular economy wherein a product can no longer be recycled and repurposed and must then be disposed of as waste material.

5 Many human made products cannot be disposed of simply without adverse effects and negative externalities to the environment, thus there is a similar desire to reduce the amount of residual waste like there is to using raw materials. The longer a material and product can remain in circular economy 100, the less raw materials are needed and the less residual

10 waste is produced. Thus the desire for an improved and sustainable environment when it comes to human made products is to maintain products within the circular economy for as long as possible, thus reducing the need for raw materials and also lessening the amount of residual waste produced. As described below, the disclosed technique is concerned with

15 the maintenance of plastic materials within the circular economy. The ability to increase the maintenance of plastic materials within the circular economy requires the ability to accurately track plastic materials along its various locations within the circular economy.

Reference is now made to Figure 2, which is a schematic

20 illustration of the circular economy as applied to the plastic supply chain, generally referenced 200, according to another embodiment of the disclosed technique. As shown, the various stages of the circular economy in Figure 1 have been expanded and applied specifically to the industry of

plastics, known as the plastic supply chain. At the top of the figure, the basic steps of the circular economy are shown, color-coded and grouped together, such as raw material production 202, base material production 204, plastic design and production 206, distribution and consumption 208 as well as recycling 210. As can be seen, the production of plastics begins with the extraction of petrochemicals 214. From there, base chemical manufacturers create plastic resins and polymers 216 which can then be converted into plastic products. Whereas petrochemicals are a completely natural resource, already at the stage of base chemical manufacturing, virgin materials as well as recycled materials can be used in the preparation of base chemicals for plastics 218. Once base chemicals are prepared, extruders and compounders 204 then prepare pre-cursor plastic materials from which plastic products 206 can be made. This includes blending polymers and additives 220 to create plastic pellets, ingots and other basic plastics pre-cursor forms from which products can be made.

Plastic products are then designed and manufactured. The products in general can fall under the category of actual plastic products for human use (electronics, bottles, furniture and the like) or as packaging products (containers, plastic wraps and the like). It is noted that the design and manufacturing of plastics is also dependent on the required grade of plastic to be used, certainly when products are designed for use in particular industries. Known grades of plastic include food grade, industry grade, automotive grade, medicine grade and the like. The production can also

include brand owners who produce their own plastic products or general producers. Produced products must then be distributed to wholesalers and then to retailers for sale to consumers 212. Consumers 212 then buy the plastic products and use them. Once their use is complete, consumers will
5 dispose of the plastic products which can be collected 222. Once collected, provided such services exist in a locality, plastic products are sorted according to their type and use. If possible, plastics are either mechanically recycled as shown by an arrow 224, thus allowing them to reenter the circular economy as manufactured plastic products as shown by an arrow
10 226, or chemically recycled as shown by an arrow 228, thus allowing them to reenter the circular economy as recycled base materials. The ability to reuse and/or remanufacture a plastic depends on its type and intended use, as well as its grade. At times, a plastic product cannot be recycled and is then either sent to a landfill, disposed of via incineration or destroyed in
15 some other way as shown by an arrow 230. The ability to properly maintain plastic products within circular economy 200 of the plastic supply chain depends on the ability to mark, track, grade, categorize and sort plastic materials along the various stages of the plastic supply chain.

Reference is now made to Figure 3, which is a schematic
20 illustration showing a marking and tracking system for plastics within the lifecycle of plastics, generally referenced 300, constructed and operative according to a further embodiment of the disclosed technique. The system of Figure 3 is based on a sub-system 302 which includes three main

components 308A, 308B and 308C. A first component 308A includes a hidden chemical-based marker that can be added to a plastic material at various stages of the production of plastic. The chemical marker is not easily detectable and maintains its integrity even as a plastic changes in chemical composition and physical form. A second component 308B includes a reader which is able to scan a plastic product for not only the presence of the chemical marker but also any information stored in the marker. The third component includes a blockchain platform 308C for storing the scanned data of the reader, thus enabling a verification of ownership and authenticity and composition of a plastic product to be ascertained.

First component 308A enables a marker (schematically shown as a chemical representation) to be placed within the base materials and pre-cursor plastic materials. As a chemical-based marker which is also hidden, the marker enables information about the base material to be stored within the base material and also enables this information to be carried forward as the pre-cursor plastic material is designed, manufactured into products, used by consumers and then collected and sorted by recyclers. As a chemical-based marker, the marker cannot be removed without compromising the chemical structure of the plastic material and product, thereby making it substantially tamperproof, unlike bar codes and other indications on a plastic product which can easily be compromised and/or removed. The marker can also be placed within a recycled plastic material,

thus enabling information about the nature of the recycled plastic material to be carried forward if and when the recycled plastic material is used by a manufacture and/or a base chemical producer. Due to the continued presence of the chemical marker throughout the lifecycle of a plastic product, the disclosed technique can be used to develop a standard by which plastics can be graded and certified at any stage of the plastic supply chain.

The chemical-based marker of the disclosed technique is a sequence of molecules that is chemically non-reactive and substantially inert to the plastic matrix molecules they are added to. The sequence of molecules is chosen depending on the type of plastic being extruded and processed and therefore must be compatible with the various stages of plastic production. As different grades and end products of plastic exist, the sequence of molecules must be chosen to be compatible with the grade of plastic being processed as well as the desired end product of the plastic. This can also include the desired stage or stages in the production of plastics as to when the chemical-based marker is to be added. For example, a marker selection process can be used to choose molecules that are compatible with plastic extrusion, compounding and converting as well as other plastic production processes. This can further include compatibility of the marker with a plastic matrix that is to be formed as part of a masterbatch, as an additive or as a plastic concentrate. It is further noted that according to the disclosed technique, the sequence of molecules must

be selected such that they meet regional and international protocols and standards regarding compliance with chemical safety pursuant to the given grade of plastic they are being mixed into. This can include compliance with regulations and standards such as CLP and REACH (both in the EU),
5 GHS and TSCA (both in the USA), CSCL and JIS (both in Japan) and CCA and K-BPR (both in South Korea), for example.

The chemical-based marker of the disclosed technique encodes information in a manner similar to barcode encryption and binary programming, thus the sequence of molecules or a particular string of
10 molecules in the sequence of molecules can be used to represent 0s and 1s to mimic the concept of binary programming. The particular list of molecules, their order as well as their concentration can thus form a chemical chain with information encoded in it. The amount and molecular weight of the chemical-based marker can thus affect how much data and
15 information can be stored.

According to the disclosed technique, the act of writing information to the chemical-based marker is executed in the formation and generation of the molecular sequence of the marker. For example, the chemical nature of the marker can be selected such that it survives the
20 different stages of manufacturing and/or life cycles of a plastic material. However the marker may also have an end of life, meaning the marker may not last more than a single plastic life cycle, with the process of recycling for example, causing the chemical marker to break up. The end of life of

the marker may be a function of heat, time and/or a particular process used in the plastic life cycle. When this occurs, then a rewriting of information can happen and a new chemical marker can be added to a plastic material to write new information. For example, an ownership of a plastic material
5 may be encoded as information in a chemical marker that only last a single plastic life cycle, thus each time a plastic material is reinserted into the life cycle, a new chemical marker is added to encode the owner of the plastic material.

In addition, according to the disclosed technique, additional
10 chains of molecules can be added to existing sequences of molecules thus allowing for further information to be added to the chemical marker. For example, the loop count of a recycled plastic can be stored in the chemical marker by adding an additional molecule chain to a given sequence for each loop count. As per the disclosed technique, 2, 3 and up to N layers of
15 additional information can be added to a chemical marker via additional chains of molecules, thus enabling a history of the chemical marker to be maintained and accessed. In practice, most plastics have a lifespan of between 5-7 lifecycles depending on the polymer type the plastic material is made from.

20 Second component 308B enables a given authenticated and marked plastic material to be accurately identified and tracked as it moves through the plastic supply chain. Thus, given the reader with its ability to read the chemical marker within a plastic material and extract the

information about the plastic material contained therein, a verification of the plastic material can be ascertained at any stage within the plastic supply chain. This enables the easy detecting of fraud and can also aid in determining where within the plastic supply chain something within the plastic material was compromised in the case of material failure. For example, if a plastic product breaks prematurely, then the authenticity of the plastic product from base material to the manufactured product can be checked using the reader to see if the authentic plastic product was indeed present throughout the supply chain. Second component 308B allows a plastic material to be tracked, not only regarding its composition but also regarding its ownership. The reader can thus extract data and information from all the layers of the chemical marker, enabling data to be read from a recent layer of molecules added to the marker and/or from an older layer of molecules in the marker.

Third component 308C enables the information gleaned from second component 308B to be stored in a data structure that prevents tampering without leaving a clear trail and also enables players and actors within the plastic supply chain to be aware of the status of a given plastic product. The data structure can be embodied as a distributed ledger, such as a blockchain. Different blockchain architectures are possible for embodying the data structure. Examples of such blockchain architectures include R3-Corda with permissioned Blockchain, Azure Blockchain and Amazon managed blockchain AWS. This allows the information scanned

at each part of the supply chain to be added to the same blockchain across localities and locations around the globe. As a distributed ledger, players and actors within the plastic supply chain can access the scanned in information of a plastic material for tracking and analysis purposes.

5 The integration of sub-system 302 within the plastic supply chain in shown in a graph 304 which shows the various main stages of the plastic supply chain. As shown, at each stage, a scan of the chemical-based marker can be made and the information culled from the scan can be uploaded to an exchange platform (herein abbreviated **EXP**) 306, as shown
10 in a legend 312. Thus players at each stage, such as compounders, brand owners, collectors and recyclers, can add information to EXP 306 as well as reference information in EXP 306. EXP 306 can be embodied as a blockchain or any type of distributed ledger. Shown as well is that at certain stages chemical-based markers 310A, 310B, 310C and 310D are added to
15 the plastic material for tracking, grading, certification and authenticity. Chemical-based markers 310A, 310B, 310C and 310D can include information about ownership of the plastic material, composition of the plastic material, percent of virgin versus recycled plastic material in the plastic product as well as the number of times a recycled plastic material
20 has been recycled. As shown, different markers can be added at different stages of the supply chain, such as during base material production (such as chemical-based markers 310A and 310B) and/or during the recycling stage (such as chemical-based markers 310C and 310D). The marker can

also include an indication relating to chemical recycling as opposed to mechanical recycling.

Reference is now made to Figure 4, which is a schematic illustration showing the integration of the marking and tracking system for plastics of Figure 3, generally referenced 400, constructed and operative according to another embodiment of the disclosed technique. Shown again are some of the various stages in the plastic supply chain, as suppliers 404, producers 406, consumers 408 and recyclers 410. An EXP 402 is shown in the middle, showing the access various players have to EXP 402.

Suppliers 404 (of raw materials, both virgin and plastic) participating in the supply chain can be provided with a workstation 412 and reader 414 for scanning pre-cursor plastic materials they supply. Thus suppliers can record aspects of the pre-cursor materials they are providing to producers, such as the composition of plastic pre-cursors as well as if and how much recycled materials are in the pre-cursor materials. Producers 406 can be provided with a workstation 416, computer 418 and reader 420 for scanning and authenticating plastic products they produce, manufacture and distribute. This can include ensuring that the raw materials they received are indeed the materials requested for the kind of plastic they are producing.

For example, a producer of medical grade plastics can scan a received pre-cursor material (i.e., the material itself and not a barcode placed on the packaging of the material) to ensure that the pre-cursor material is indeed medical grade and can be used for medical grade plastic manufacturing.

Whereas individual consumers cannot scan plastic products with a reader, they can nonetheless access EXP 402 through a network-based terminal (such as a personal computer, laptop, tablet, smartphone and the like connected to a network) to verify the authenticity of a plastic product they own and also see and determine its composition and other information stored in EXP 402. Third party players, such as NGOs and financial investors (not shown in Figure 4) can also access EXP 402 like consumers. Recyclers 410, like producers 406, are supplied with a workstation 422, computer 424 and reader 426 for accessing EXP 402 and can add scanned information to EXP 402. Not shown is that during the stages of suppliers and recyclers, chemical-based markers can be added to the plastic materials for further classification, grading, categorization and certification. As explained further below, after a recycler has recycled a plastic material and essentially reinserted it into the plastic supply chain (i.e., by verified sale of the recycled plastic to a plastic supplier), EXP 402, based on the scanned information stored therein, can issue a certification regarding the recycled plastic material. The certification can then be used by the recycler to acquire tokens which can be used as credit in a trading platform, as described above. The certification afforded by the disclosed technique and the issuance of tokens is not restricted to just the recycling stage and can be implemented in any stage of the plastic supply chain depending on pre-set criteria for grading, certification and issuance of tokens.

Reference is now made to Figure 5, which is a schematic illustration showing the marking and tracking system for plastics wherein tokenization is possible, generally reference 500, constructed and operative according to a further embodiment of the disclosed technique. Shown again
5 in Figure 5 is the plastic supply chain 502 in a circular economy with the various actors and players 504, 506, 508 and 510 in the industry, minus consumers. The use of the marking and tracking system of the disclosed technique enables the creation of plastic tokens 512 (i.e., the act of tokenization) which can be used in a trading platform for trading plastics as
10 a commodity, shown schematically as a plurality of arrows 514 between the different stages of the plastic supply chain. The plastic tokens are substantially physical and/or digital entities which are valued according to a given quantity of plastics (for example one ton of plastics) based on the composition of the plastic material. This can include the grade of the plastic
15 material, the composition of the plastic material, the virgin versus recycled material composition of the plastic material, the loop count regarding recycling cycles of the plastic material and the like. Because data about the plastic material is not only encoded physically into the plastic material and therefore always present in the plastic supply chain, but also uploaded
20 and stored in an EXP (not shown), the veracity of a plastic material regarding its source and nature can be monitored and maintained virtually free of fraud. This allows for a trustworthy issuance of tokens representing the given quantity of plastics. Tokens have equivalent monetary value as

credit and are controlled according to information from the EXP. The authenticity of tokens representing actual plastics as a commodity can be substantially guaranteed by the disclosed technique due to the marking and tracking system of the EXP which ensures that legit commodities are being

5 traded and not fake recycled plastics or plastics for which their authenticity cannot be verified. The value of tokens can be incentivized by offering breaks and benefits for more sustainable practices while levying further costs for practices that include higher amounts of externalities. For example, suppliers may be charged higher amounts of tokens for

10 purchasing raw materials in order to make plastics, however those same suppliers may acquire tokens at a lower price from other players in the supply chain if they purchase chemically recycled plastics for making their base materials. As another example, recycled base materials having 60% recycled materials may have higher value in tokens than recycled base

15 materials having 20% recycled materials. Many other examples exist of how the disclosed technique can be used in tokenizing a given quantity of plastics to enhance the veracity of plastic tokens for use in such a trading platform wherein the authenticity of the plastic material can be verified and certified and wherein tampering with the material composition of a plastic

20 material is nearly impossible without chemically changing the plastic.

Reference is now made to Figures 6A and 6B, which are schematic illustrations of a marking and tracking system for plastics according to respectively a flexible loop construction and a rigid loop

construction, generally referenced 600 and 650 respectively, constructed and operative according to another embodiment of the disclosed technique. With reference to Figure 6A, a flexible loop construction is shown, schematically showing the various stages of the plastic supply chain wherein chemical markers are added, scans of the chemical marker and thus verification of the plastic product is sent to an exchange platform 602 for tracking purposes and in which players within the supply chain provide information to the exchange platform. For example, a base chemical manufacturer (herein abbreviated **BCM**) 604 adds markings to a virgin plastic material it has manufactured regarding the manufacturer (denoted as marker 'A') and the plastic type (denoted as marker 'D'). As shown via an arrow 605A, scanning can be used by BCM 604 when recycled materials are used in the manufacturing of virgin plastic materials to ascertain the manufacturer and plastic type, as well as to update the marking in case of a transfer of ownership (herein abbreviated **TOO**). As shown via an arrow 605B, scanning can also be used to verify the markings of a plastic material before it is shipped off to a plastic converter 606. As shown by an arrow 607A, plastic converter 606 can authenticate and verify that the received plastic material is indeed the ordered plastic material matching the expected manufacturer and plastic type as stored in exchange platform 602. Plastic converter 606 transforms a plastic roll into plastic pouches. As shown by an arrow 607B, the marking of the plastic material can then be updated to indicate the source of the plastic pouches, for example which

roll, which lot number and the weight of the roll from which the plastic pouches were made. As shown, even retailers 608 can use scanning to authenticate the plastic product they are selling from a distributor (not shown) and also to update a TOO of the plastic material from which the plastic product was made from. As shown, a first store 610 and a second store 612 can update exchange platform 602 that a plastic product was sold and also, if a plastic product is returned to the store for collection, then how the plastic product should be sorted according to the stored plastic type on the marking of the plastic product. As shown, the tracking and subsequent grading and categorization of a plastic product can be used by a waste collector 614 to easily sort plastics according to the information stored in the chemical marker in a plastic product, such as weight, bale number and plastic type. Shown as well is the ability of a recycler 616 to use the information from the exchange platform, based on an AI-driven algorithm, to determine what a given collected plastic material should be recycled into. One example shows that a given bale should be recycled and transformed into pellets, wherein a marking can then be given to the pellets that they've been recycled once (thus loop count = 1). As shown, the scanning of a plastic material can track the TOO as well. In the flexible loop construction of Figure 6A, the chemical marker only includes information related to the manufacturer and the plastic type.

The AI-based algorithm of the disclosed technique can be based on the Monte Carlo method for optimization, wherein two data layers are

used for determining a most suitable use of a recycled plastic. The first data layer can include all the historical and present chemical data of the plastic material, such as its status as virgin material, converted material, life cycle loop count, previous product use and the like. The second data layer
5 can include all the historical and present commercial data regarding the application of the plastic material and its intended commercial market, its pricing as well as the regulations of the plastic articles the plastic is being used for.

More specifically, inputs for the first layer can include the type of
10 monomer/polymer of the plastic, resin and chemical components of the plastic, MSDS and TSD material data sheets, the core chemical properties of the plastic (such as base plastic material being PE (polyethylene) or PP (polypropylene), single layer/multi-layer plastic), the grade-type of plastic, the intended use of the plastic material (such as extrusion, molding, casting,
15 colorant or additive) and the like. Inputs for the second layer can include application and commercial data, bottling/packaging data, status of the plastic as a primary/secondary plastic, regulations which the plastic needs to comply with, geographic location of previous life cycle plastic material manufacturing, brand ownership and the like.

20 Nodes in the first layer data can be used to decide the future of a plastic material, meaning what can the plastic material be used for in another life cycle. The second layer data can be used to define the future value of the plastic material as a product, meaning its recommended price,

the quantity of product that can be produced with the plastic as well as the future life span of the plastic product (e.g., how many times can it be recycled and reinserted into the plastic life cycle?).

With reference to Figure 6B, a rigid loop construction is shown,
5 also schematically showing the various stages of the plastic supply chain wherein chemical markers are added, scans of the chemical marker and thus tracking and verification of the plastic product is sent to an exchange platform 652 and in which players within the supply chain provide information to the exchange platform. Whereas the rigid loop construction
10 is similar to the flexible loop construction of Figure 6A, the chemical marker now includes information related to the manufacturer, the plastic type, the loop count and the percent of recycled material. Such information can also be used to further improve an AI-driven algorithm for determining the best use of a collected plastic material which is to be recycled.

15 It is noted that the AI-driven algorithms of the disclosed technique can also be used to improve the sorting process of recycled plastics by adding finer granularity to the sorting process. This can be accomplished by having more data and information available about a given plastic pellet which is to be sorted for recycling, such that it can be more appropriately
20 sorted and a best use in a future life cycle can be determined. In this embodiment of the disclosed technique, an AI-driven algorithm based on the Monte Carlo method of optimization can be used having a single data layer. The input nodes in this data layer can include the following factors:

geographical information regarding the plastic material, the year it was made, the brand owner, the type of plastic, the polymer family it belongs to and its layer status, the polymer type, the amount of recycled content, the loop count of the plastic material and the like. All of these factors can be
5 used according to the disclosed technique to train an AI-driven algorithm to sort a plastic material.

Reference is now made to Figure 7, which is another schematic illustration showing the marking and tracking system for plastics wherein grading and certification is shown leading to tokenization, generally
10 referenced 700, constructed and operative according to a further embodiment of the disclosed technique. As shown, at the center of the supply chain of plastics is an EXP 702 which stores information about the chemical marker and thus of a plastic as it moves from stage 1 (shown as stage 704) to stage 8 (shown as stage 706). Whereas chemical markers
15 are only added at stages 1, 2 and/or 3 and also at stages 7 and/or 8, in each stage a scan of the chemical marker is taken to update the information in EXP 702 regarding ownership and also composition of the plastic material. Due to the presence of the chemical marker through all stages of the plastic supply chain, a standard is possible that such when a plastic
20 material gets to stage 8, a grade 708 as well as a categorization of the plastic material can be made. The grade may be an indication, based on the data in EXP 702, as to what grade of plastic the recycled plastic material in stage 8 can be used for, for example, automotive grade, food grade,

technology grade, medical grade and the like. The grade assigned to the recycled plastic material in stage 8 may not be the same as a grade assigned to the virgin plastic material in stage 1. For example, a plastic material may start as a food grade plastic in stage 1 but be graded as an automotive grade plastic in stage 8 when the plastic material is recycled. The grading can also be used as input to an AI-driven algorithm to categorize the best use of the recycled plastic material as it reenters stage 1. The grading can also be used to enable more efficient sorting of the plastic material due to its grade, which is stored in the chemical marker and available for viewing from EXP 702. The grading system is uniform since the chemical markers of the plastic material are present throughout all stages of the supply chain, thus enabling a standardization of how recycled plastics are graded.

As shown, once a grade has been assigned, a certificate 710, either digital or physical, can be issued for the recycled plastic material. The certificate may be assigned to a given recycler who can then present it to a supplier purchasing recycled plastic materials for making new plastic base materials and pre-cursor materials. Certificate 710 is a guarantee as to the quality of the recycled plastic being reinserted into the plastic supply chain, for example what percent of the plastic material is recycled and what percent is virgin, what grade does the plastic have, who is the current owner of the plastic material, and the like. As mentioned above, with the issuance of a certificate, tokenization 712 is possible in which a token 714 (as shown

next to stage 8) can be awarded to a recycler for the certificate achieved for a given recycled plastic material. Token 714 can be exchanged for credit which may have actual economic value. However tokens can also be traded between the different stages of the plastic supply chain, similar to a commodity. As a plastic material loops from stages 1 to 8 more than a single time, increased values of the token can be assigned as incentive for repeat recycling. Thus 2, 3 and N lifecycles of a plastic marker will increase the numbers of tokens that can be issued at stage 8. Tokens thus represent the value of a given quantity of plastic material and can be converted into credit if desired. As shown in Figure 7, once tokens are issued, they can be traded amongst players in the plastic supply chain at any stage (shown via plurality of arrows 716). Thus the tokens of the disclosed technique can be used to unite all players in the lifecycle of plastics in a market. As mentioned above as well, tokens can be valued such that they grant positive or negative credit, depending on the quality of a plastic product at a given stage in the plastic supply chain.

It will be appreciated by persons skilled in the art that the disclosed technique is not limited to what has been particularly shown and described hereinabove. Rather the scope of the disclosed technique is defined only by the claims, which follow.

CLAIMS

1. Method for characterizing a plastic material, comprising the procedures of:
 - marking a plastic material using a chemical-based marker, said
 - 5 marker comprising information related to at least one of:
 - an ownership of said plastic material;
 - a polymer type of said plastic material;
 - an intended use of said plastic material;
 - a loop count denoting a number of times said plastic
 - 10 material has been recycled; and
 - a percentage of recycled content in said plastic material,
 - and
 - recording said information in an exchange platform,
 - wherein said recording enables increased tracking and
 - 15 utilization of said plastic material.
2. The method according to claim 1, wherein said chemical-based marker is a sequence of molecules meeting at least one of an accepted standard for chemical safety.
- 20
3. The method according to claim 1, wherein said information is encoded in said chemical-based marker via a sequence of molecules representing binary programming.

4. The method according to claim 1, wherein said exchange platform is a distributed ledger system implemented on a computing platform.
- 5 5. The method according to claim 1, wherein said exchange platform is implemented as a blockchain architecture selected from the list consisting of:
- R3-Corda with permissioned Blockchain;
- Azure Blockchain; and
- 10 Amazon managed blockchain AWS.
6. The method according to claim 1, wherein said recording is accessible on said exchange platform to at least one industry player.
- 15 7. Method for categorizing a most suitable use of a recycled plastic material, comprising the procedures of:
- recording information about said recycled plastic material in a distributed ledger, said information comprising at least one of:
- a polymer type of said recycled plastic material;
- 20 an intended use of said recycled plastic material;
- a loop count denoting a number of times said recycled plastic material has been recycled; and

a percentage of recycled content in said recycled plastic material,

and

inputting said information in an AI-driven algorithm,

5 wherein said AI-driven algorithm can determine said most suitable use for said recycled plastic material based on said information, thereby enabling optimal and efficient allocation of said recycled plastic material for sustainability benefits.

10 8. The method according to claim 7, wherein said distributed ledger is implemented as a blockchain architecture selected from the list consisting of:

 R3-Corda with permissioned Blockchain;

 Azure Blockchain; and

15 Amazon managed blockchain AWS.

9. The method according to claim 7, wherein said AI-driven algorithm is based on a Monte Carlo method of optimization.

20 10. The method according to claim 7, wherein said AI-driven algorithm comprises two layers of data.

11. The method according to claim 10, wherein a first data layer of said two layers of data comprises historical and present chemical data of said recycled plastic material and wherein a second data layer of said two layers of data comprises historical and present commercial data of said recycled plastic material.

12. Method for determining a standard value of a plastic material, wherein said plastic material is marked by a chemical-based marker, taking into account a determination of at least one externality in at least one stage in a plastic supply chain, comprising the procedures of:

determining a market value of a predetermined quantity of said plastic material;

determining said at least one externality in said at least one stage in said plastic supply chain;

assigning a negative market value to said at least one externality; and

producing said standard value of said plastic material using said market value and said negative market value,

wherein said negative market value reflects costs associated with environmental impacts and sustainability.

13. The method according to claim 12, wherein said at least one externality is selected from the list consisting of:

pollution;
physical health impacts on humans;
physical health impacts on the environment;
social health impacts on humans; and
5 social health impacts on the environment.

14. The method according to claim 12, wherein said negative market value
is assigned based on at least one factor selected from the list
consisting of:
10 widespread impact on environmental pollution;
widespread impact on human health;
a higher-order externality;
data obscurity of a market player in said plastic supply chain;
a responsibility of said market player in said plastic supply
15 chain;
geographic variation;
environmental conditions; and
waste management infrastructure.

20 15. The method according to claim 12, wherein said at least one stage is
selected from the list consisting of:
production;
manufacturing;

distribution;
consumption;
recycling; and
disposal.

5

16. The method according to claim 12, wherein said at least one externality is defined as a metric taking into account at least one environmental factor.

10 17. The method according to claim 16, wherein said at least one environmental factor is selected from the list consisting of:

environmental impact of said at least one stage; and
sustainability of said at least one stage.

15 18. Method for sorting a plastic material, comprising the procedures of:
recording information about said plastic material in a distributed ledger, said information comprising at least one of:

a polymer type of said plastic material;

an intended use of said plastic material;

20 a loop count denoting a number of times said plastic material has been recycled; and

a percentage of recycled content in said plastic material,

and

inputting said information in an AI-driven algorithm,

wherein said AI-driven algorithm can determine if said plastic material can be recycled for said intended use of said plastic material; and

5 wherein said AI-driven algorithm can determine a new application of said plastic material if said plastic material is determined to have finished a lifecycle in said intended use of said plastic material, thereby enhancing a sustainability of said plastic material and reducing waste.

10

19. The method according to claim 18, wherein said distributed ledger is selected from the list consisting of:

R3-Corda with permissioned Blockchain;

Azure Blockchain; and

15

Amazon managed blockchain AWS.

20. The method according to claim 18, wherein said AI-driven algorithm is based on a Monte Carlo method of optimization and comprises one layer of data.

20

21. The method according to claim 20, wherein said one layer of data comprises at least one factor selected from the list consisting of:

geographical information regarding said plastic material;

year of production of said plastic material;
brand owner of said plastic material;
type of said plastic material;
polymer family of said plastic material;
5 layer status of said plastic material;
polymer type of said plastic material;
amount of recycled content in said plastic material; and
loop count of said plastic material.

- 10 22. Method for grading a plastic material, comprising the procedures of:
marking a plastic material using a chemical-based marker, said
marker comprising information related to at least one of:
an ownership of said plastic material;
a polymer type of said plastic material;
15 an intended use of said plastic material;
a loop count denoting a number of times said plastic
material has been recycled; and
a percentage of recycled content in said plastic material,
and
20 recording said information in an exchange platform,
wherein said recording enables increased tracking and
utilization of said plastic material throughout a lifecycle of said plastic
material;

wherein said recording in a recycled stage of said plastic material is used to assign a grade to said plastic material, wherein said grade is homogeneous based on said chemical-based marker; and

5 wherein said grade can be used to certify said plastic material.

23. The method according to claim 22, wherein said chemical-based marker is a sequence of molecules meeting at least one of an accepted standard for chemical safety.

10

24. The method according to claim 22, wherein said information is encoded in said chemical-based marker via a sequence of molecules representing binary programming

15 25. The method according to claim 22, wherein said exchange platform is a distributed ledger system implemented on a computing platform.

26. The method according to claim 22, wherein said exchange platform is implemented as a blockchain architecture selected from the list
20 consisting of:

R3-Corda with permissioned Blockchain;

Azure Blockchain; and

Amazon managed blockchain AWS.

27. The method according to claim 22, wherein said recording is accessible on said exchange platform to at least one industry player.
- 5 28. The method according to claim 22, wherein said grade comprises a homogeneous set of data regarding a quality of said plastic material with industry relevance.
29. The method according to claim 22, wherein said certifying of said
10 plastic material can be used to tokenize said certified plastic material.
30. The method according to claim 22, wherein said tokenized plastic material is assigned a monetary value.