COMPUTER-IMPLEMENTED METHOD FOR SORTING OF PLASTIC COMPOUNDS

FIELD OF THE INVENTION

The present disclosure relates to a computer-implemented method for sorting of plastic compounds, a computer-program element for such a method, a computer readable medium storing such a computer-program element, a plastic compound sorting device, a system for sorting of plastic compounds and a use of a computer-based database in such a method.

BACKGROUND OF THE INVENTION

Plastics show substantial benefits in terms of low weight, durability, low cost, applicability at wide temperature ranges, good temperature and light resistance as well as easy processing capabilities. Due to these benefits, the global demand of plastic increases every year and therefore the global production of plastic comprises a three-digit amount of million tons a year. A significant share of plastic is used for packaging, automotive, electrical goods. After use or end of lifetime only a small share of the generated plastic waste is reused. Recycling of plastic poses an option to reduce plastic waste and to save natural resources. Recycling of plastic waste requires separation and a sorting of the plastic waste due to the big variety of polymer types, grades, blends and/or additives. Therefore, sorting is a major issue for recycling of plastic waste. Recycling has a significant effect on economic aspects of recycling of plastic waste and on a sustainability of plastics in a value chain.

In view of this, it is found that a further need exists to provide a method for recycling plastics.

SUMMARY ~~OF THE INVENTION~~

It is therefore an object of the present ~~invention~~ disclosure to provide a method control and improve sorting of plastic compounds.

These and other objects, which become apparent upon reading the following description, are solved by the subject-matter of the independent claims. The dependent claims refer to preferred ~~embodiments~~examples of the present disclosure.

According to a first ~~aspect~~ example of the present disclosure a computer-implemented method for sorting of plastic compounds is provided, comprising the steps of: providing a computer-based database comprising entries on a plurality of markers each identifying a specific plastic compound; receiving scan data from a sample of a plastic compound; identifying a marker in the sample of

the plastic compound based on the received scan data and the plurality of markers of the database; sorting of plastic compounds based on the identified marker of the sample of the plastic compound.

In an aspect, there is provided a computer-implemented method for controlling sorting of plastic compounds, comprising the steps of:
providing a computer-based database comprising entries on a plurality of markers each identifying a specific plastic compound (S100);
receiving scan data from a sample of a plastic compound (S200);
identifying a marker in the sample of the plastic compound based on the received scan data and the plurality of markers of the database (S300);
sorting of plastic compounds based on the identified marker of the sample of the plastic compound (S400).

In other words, the present disclosure proposes to tag unambiguously a plastic compound with markers and thereby generating an ID for the plastic compound. Properties of the plastic compound such as polymer type, grade, blend, number of reuse, sustainability score etc. are assigned to the ID. Information data of the ID and the properties of the plastic compound are stored in a database. By scanning, the plastic compound, the markers and therefor the ID of the plastic compound are determined and matched with the database. The result of the matching reveals the properties of the plastic compound such as the type of the plastic or the content of recycled material or the sustainability score. Hence, it is possible for a user, e.g. a recycling company of plastic parts, to sort the plastic compounds, or e.g. a retailer of products to sort plastic compounds in reverse vending machines.
The proposed method may be advantageous to sort plastic compounds consisting of different material layers and different material combinations. The proposed method may be advantageous to sort between recycled and non-recycled plastic compounds. The proposed method may be further advantageous to sort between food and non-food grade plastic compounds. The proposed method may be further advantageous to sort according to the number of recycling loops of the plastic compound. The proposed method may be further advantageous, because sorting is not sensitive to the color of the plastic compound. The proposed method may be further advantageous, because sorting is possible through shrink labels.
The proposed method is not limited to the end of life / recycling step in the plastic value chain but can be used for any purpose in any step of the plastic value chain. The method could for instance be used for an improved customer interaction/experience in the retail of plastic compounds such as plastic packaging. The proposed method may be advantageous for establishing an efficient recycling economy of plastic parts. The proposed method may be further advantageous to serve as a basis for product curriculum vitae comprising the sustainability score, and wherein further information (e.g. produced products with the specific plastic compound) is added to the curriculum vitae and stored in database. The proposed method may further be

advantageous to reduce plastic waste and to increase an amount of recycled plastic waste. : The proposed method helps to minimize material cross-contamination and maximizes the quality and subsequently the value of the reprocessed plastic compounds. The proposed method can also be used to trigger material exit from mechanical recycling loop to other recycling possibilities, namely chemical recycling, thermal recycling (incineration) or organic recycling.

The term sustainability score is to be understood broadly in the present case and comprises a figure configured to present information about the sustainability of a plastic compound, wherein the sustainability preferably relates to the content of recycled material of the plastic compound and/or the number recycling loops of the recycled material of the plastic compound. The sus-

tainability score may comprise a metric, e.g. a verbal coding “bad”, “good”, “very good” or a color coding “red”, “orange”, “green” or a number coding “1”,”2” ,”3”. The sustainability score is not limited to the mentioned examples. The sustainability score may be based on data submitted by a master batcher and converter for an OEM, a Retailer, or End customer. The term computer-based database is to be understood broadly in the present case and comprises any database or data system, which is configured to store and manage data. The database may be central or decentral organized and may comprise different access authorizations to different users (e.g. read, read/write etc.). The database may be stored and executed on a cloud server. The database may be realized as a block chain network. The block chain may increase a protection against fake data and therefor increase the trust of customers. The block chain may increase analysis capabilities (e.g. determining loop number of recycled plastic compound). The term entry is to be understood broadly in the present case and comprises any data, which can be stored in a database, preferable the term entry relates to an ID of a plastic compound in the present case, e.g. a binary code. The term marker is to be understood broadly in the present case and comprises elements configured to disclose an information relating to a plastic compound ID. The term marker may comprise chemical tracers, i.e. molecules embedded in the plastic resin, acting as a binary code as the molecule is either present or not. Such chemical tracers show various spectroscopic properties and are therefore detectable (e.g. being florescent under UV light). By adding different chemical tracers, each with unique spectra, it is possible to create codes, which serve as entries of the database. These chemical tracers may be advantageous because they are insensitive to deformation or other physical stress and hence improve the detectability of plastic compound during the life cycle. The term marker may further comprise QR-data, digital watermarks, barcodes. The term scan data is to be understood broadly in the present case and comprises any data received from a scan and/or a detection process. Preferably, scan data comprises data from spectroscopic analysis and optical scanner (e.g. a camera of smartphone). The term plastic compound is to be understood broadly in the present case and comprises any plastic material in any possible stages of the life cycle or value chain of the plastic material. Preferably the term plastic compound comprises plastic feedstock (e.g. PE, PP, PET feedstock), semi-processed plastic material (e.g. semi-finished electronic and/or car interior parts, finished plastic material (e.g. PET bottle, packaging).

In an ~~embodiment~~example the computer-implemented method comprises the steps of: receiving a block chain storing a plurality of scan data of samples, a plurality of identified markers of samples and/or a plurality of sorting decisions of samples; uploading into the block chain the received scan data of the sample, the identified marker of the sample and/or the determined sorting decisions of the sample. The term block chain is well known in the state of the art and comprises in the present case a growing list of data/records that are linked using cryptography. The data/records comprise in the present a plurality of scan data of samples, a plurality of identified markers of samples and/or a plurality of sorting decisions of samples. The data/records are not limited to these examples. The data/records may also comprise timestamps and transaction

data and related data to products of the sample (e.g. feedstock, semi-finished product, end product). By uploading a plurality of scan data of samples, a plurality of identified markers of samples and/or a plurality of sorting decisions an open ledger is extended due to a new record/entry. The ledger may be a distributed ledger, wherein every user may have a copy and may be able to generate a new entry and wherein the new entry may have to be validated by every user. In sum, this may be advantageous to increase a transparency of different stages of the life cycle and/or treatments of a specific plastic feedstock. This may further generate new data points related to the specific feedstock compound and increase analysis capabilities. This may further protect a user from deceptive entries /data related to a specific plastic feedstock (e.g. plurality of identified markers leads to fake data and reveals a deceptive sorting decision due to logic errors detected in the block chain). In other words, the scan data of specific plastic feedstock is recorded in the block chain at a transaction (e.g. any scan) and hence reveal the curriculum vitae of the feedstock and further products related to the feedstock (e.g. semi-finished product, product, waste). By use of a block chain, an authentication data may be provided based on data entries stored by upstream users along a life cycle of the feedstock compound. For access to the authentication data and sorting decisions an app may be used by customer/user.

In an ~~embodiment~~example the step of controlling sorting of plastic compounds comprises: identifying in the block chain at least one data entry associated with the identified marker of the sample; controlling sorting of plastic compounds based on the at least one data entry and the identified marker. In other words the identified markers of the sample are matched with existing entries comprising the identified markers. This may reveal the history of the specific plastic feedstock. This may reveal the number of reuses/loops of a specific plastic feedstock. E.g. a specific plastic feedstock is produced for plastic bottles, in case you find the specific plastic feedstock in another product (e.g. tooth brush) you can derive a reuse of the specific plastic feedstock. This may be advantageous to refine the sorting of plastic compounds.

In an ~~embodiment~~example, the step of identifying the marker comprises determining a type and/or a quantity of the marker in the sample of the plastic compound. The type of the marker may comprise the elements of the periodic system and combinations thereof. By determining the type of the marker, the ID of the specific plastic feedstock is determined. By determining the quantity of the marker the share of recycled plastic feedstock may be determined. This may be advantageous to control the sorting decision. The determining of the marker may comprise UV detection technique, a near infra-red detection technique, mid infra-red detection technique, an X-ray fluorescence detection technique, neuron activation technique or a magnetic detection technique, e.g. NMR.

In an ~~embodiment~~example, the step of identifying the marker comprises determining a weight portion of the marker in the sample of the plastic compound. By determining the marker and its volume

content in a sample, you can also derive the weight content by calculation. Quanitfication can also be done by determining the relative ratio of different marker systems in the sample. This may be advantageous to refine sorting of plastic compounds due to a more specific description of the material composition of the sample of the plastic compound.

In an ~~embodiment~~example a method is provided, wherein the marker is selected from the group consisting of UV marker, NMR marker, IR marker, XRD marker, XRF marker, QR code and/or steganographic feature.

In an ~~embodiment~~example a method is provided, wherein further information is added to specific plastic compound by a user executing the method, wherein the further information preferably comprises a stage in value chain and/or a product type. This may be advantageous to certify recycled content.

In an ~~embodiment~~example a method is provided, wherein user of the block chain validate every new entry. This may advantageous to increase protection against fake entries.

In an ~~embodiment~~example a method is provided, wherein the sample of the plastic compound comprises one or more elements selected from the group consisting of: low density polyethylene (LDPE), linear LDPE (LLDPE), high density polyethylene (HDPE), polyoxmethylene (POM) polypropylene (PP), polyamide (PA), poly ethylene terephthalate (PET), poly butylene terephthalate (PBT), acrylnitril-butadiene-styrene (ABS), polymethylmethacrylate (PMMA), thermoplastic polyurethane (TPU), polystyrene (PS), polylactic acid (PLA), polyvinylchloride (PVC) or polycarbonate (PC).

In another aspect, there is provided the use of of a computer-implemented method as defined above for recycling of plastic compounds

In another aspect, there is provided the use of a computer-implemented method as defined above for mechanical recycling of plastic compounds, wherein the plastic compounds exited from sorting process goes to other recycling possibilities, preferably chemical recycling, thermal recycling (incineration) and/or organic recycling.

A further aspect of the present disclosure relates to a ~~C~~computer-program element, which, when executed, instructs a processor to perform any one of the steps of the above described method. The computer program element might therefore be stored on a computing unit, which might also be part of an ~~embodiment~~example. This computing unit may be configured to perform or induce performing of the steps of the method described above. Moreover, it may be configured to operate the components of the above described system. The computing unit can be configured to operate automatically and/or to execute the orders of a user. A computer

program may be loaded into a working memory of a data processor. The data processor may thus be equipped to carry out the method according to one of the preceding ~~embodiment~~examples. This ~~exemplary embodiment~~example of the present disclosure covers both, a computer program that right from the beginning uses the present disclosure and computer program that by means of an update turns an existing program into a program that uses the present disclosure. Moreover, the computer program element might be able to provide all necessary steps to fulfil the procedure of an ~~exemplary embodiment~~example of the method as described above. According to a further ~~exemplary embodiment~~example of the present disclosure, a computer readable medium, such as a CD-ROM, USB stick or the like, is present-

ed wherein the computer readable medium has a computer program element stored on it which computer program element is described by the preceding section. A computer program may be stored and/or distributed on a suitable medium, such as an optical storage medium or a solid state medium supplied together with or as part of other hardware, but may also be distributed in other forms, such as via the internet or other wired or wireless telecommunication systems. However, the computer program may also be presented over a network like the World Wide Web and can be downloaded into the working memory of a data processor from such a network. According to a further ~~exemplary embodiment~~example of the present disclosure, a medium for making a computer program element available for downloading is provided, which computer program element is arranged to perform a method according to one of the previously described ~~embodiments~~examples of the present disclosure.

A further aspect of the present disclosure relates to a ~~C~~computer readable medium storing the above described computer program element.

A further ~~aspect~~ example of the present disclosure relates to a plastic compound sorting device, comprising: a wavelength scanner; a programmable controller; wherein the wavelength scanner is configured for scanning a sample of a plastic compound; wherein the programmable controller is configured for sorting plastic compounds by means of the above described method. The term wavelength scanner is to be understood broadly in the present case and comprises a scanner that is configured to determine a wavelength of an atom or a molecule.

In another aspect, there is provided a plastic compound sorting device (10), comprising:

a wavelength scanner (11);

a programmable controller (15);

wherein the wavelength scanner (11) is configured for scanning a sample of a plastic compound (16);

wherein the programmable controller (15) is configured for sorting plastic compounds by means of the method as defined above.

The term wavelength scanner comprises scanners based on UV detection technique, a near infra-red detection technique, mid infra-red detection technique, an X-Ray fluorescence detection technique or neuron activation technique. The term programmable controller is to be understood broadly in the present case and comprises controller, which are configured to be programmed and controlled to execute the method described above. The term programmable controller comprises preferably a CPU of a smartphone, tablet, desktop pc, or a cloud. In this content, the plastic compound handling device preferably comprises a user interface, wherein the user interface is configured for displaying the determined sustainability score (e.g. display of a smartphone).

A further exampleaspect of the present disclosure relates to a system for sorting of plastic compounds, comprising: a computer-based database comprising entries on a plurality of markers each identifying a specific plastic compound; at least one receiving unit configured to receive scan data from a sample of a plastic compound; at least one processing unit configured to identify a marker in the sample of the plastic compound based on the received scan data and the plurality of markers of the database; at least one sorting unit configured to sort plastic compounds based on the identified marker of the sample of the plastic compound.

In an aspect, there is provided a system (30) for sorting of plastic compounds, comprising:
a computer-based database (31) comprising entries on a plurality of markers each identifying a specific plastic compound;
at least one receiving unit (32) configured to receive scan data from a sample of a plastic compound;
at least one processing unit (33) configured to identify a marker in the sample of the plastic compound based on the received scan data and the plurality of markers of the database (31);
at least one sorting unit (34) configured to sort plastic compounds based on the identified marker of the sample of the plastic compound.

The receiving unit and/or processing units may be distributed hardware components (e.g. separate CPUs), virtual components on one hardware component (e.g. central CPU). The receiving unit may comprise an interface with a specific communication standard (e.g. Ethernet, USB, HTML, NFC, Bluetooth,

PCI etc.). The sorting unit may mechanically sort the plastic compunds, e.g. by means of a controllable air current.

A last aspect of the present disclosure relates to a use of a computer-based database comprising entries on a plurality of markers each identifying a specific plastic compound and/or scan data from a sample of a plastic compound in a method described above.

In an ~~embodiment~~example, the step of identifying the marker comprises determining parameters from the previous lifecycle of the plastic compound based on the identified marker in said sample of the plastic compound and/or determining the content of recycled plastic of the plastic compound. Lifecycle refers to the period from production of the plastic compound till disposal and recycling of the same. The identified markers may be associated with a specific product and may therefor reveal the parameters from the previous lifecycle of the plastic compound. A share of determined markers in the sample may reveal the content of recycled plastic of the plastic compound. A material recycler may adapt the share of markers in the plastic compound each time he produces a plastic compound. In sum, this may be advantageous to refine the sorting of plastic compounds. For example every time a material recycler produces a plastic compound an additional marker may be added to the plastic compound. The marker may indicate the number of times the plastic compound has been recycled.

The exit of plastic compound from sorting process preferably to other recycling possibilities, very preferably from e.g. mechanical recycling to chemical recycling, to thermal recycling (incineration) and/or to organic recycling, can be triggered based on the determined number of lifecycles and/or content of recycled plastic of the plastic compound.

In an further ~~embodiment~~example, the determined number of lifecycles and/or content of recycled plastic of the plastic compound can also be used to trigger the exit of a plastic compound from a closed loop recycling process, e.g. recycling of plastic bottles, to another application, e.g. non-food contact packaging material.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following, the present disclosure is described exemplarily with reference to the enclosed figure, in which

Figure 1 is a schematic overview of the steps of a method according to the present disclosure;