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NANO TECHNOLOGY ENABLED RECYCLING EXCHANGE FOR WASTE REDUCTION

Nidhi Sharma[*1], Dr Sushil Kumar[2] and Dr Ramesh Kumar[3]

[*1]Bharti College of Engineering & Technology, Phulgaon Chowk, Durg

[2]Principal, Pragati College of Engineering & Technology, Raipur

[3]Professor, Computer Sc & Engineering, Bhilai Inst of Technology, Bhilai

ABSTRACT

The current trend of invasion of technological advancement and particularly in nano region has paved ways for identification through embedded identifier in the products for tagging and tracking of products is possible. This tagging and tracking will facilitate the manufacturer to keep record of the product and its condition. The known condition will alert the manufacturer to go for routine maintenance and increase efficiency of product during its life time. The condition of recycling and need is always made available to the agencies whose responsibility is to take care of product when it is market. Proper data maintenance in the Recycling Exchange will serve the dual purpose of record keeping and issuing alerts for the conditions for improvement in efficiencies. The proper maintenance and extraction of resources from the end of life products will enable to minimize the waste and increase in the resource for sustainable development.

Keywords- *Nano Material, Nanochip, Nanotech, Tagging, Tracking, Recycling Exchange, Waste Minimization, Sustainable Resource Development, Pallet.*

I. INTRODUCTION

Pollution means the presence in or introduction into the environment of a substance which has harmful or poisonous effects (Internet) and as per Business Dictionary it means Presence of matter in any form i.e. gas, liquid, solid or energy in either forms i.e. heat, noise, radiation whose nature, location, or quantity directly or indirectly alters characteristics or processes of any part of the environment, and causes or has the potential to cause damage to the condition, health, safety, or welfare of animals, humans, plants, or property. In a broader positive sense Pollution can be seen as resources which we feel is unwanted, do not harvest and allow them to disperse because we've been ignorant of their value." The rising level of global consumption, shrinking supply of resources, limited technology and space for overcoming these pollutants we need to go extensively for resource recycling, using possible pollutions and come to a zero waste situation. Pressed scenario of limited landfill space for tackling wastes, increasing regulatory and consumer pressure for buy backs or extended producer responsibility, there is a growing need to track materials for recycling and reuse throughout product lifecycles and ensure that products are disposed off and recycled repeatedly to fullest extent responsibly. Even after optimal use one is bound to get some waste and these wastes proper disposal in scientific manner is beneficial for the environment which will ensures that the thousands of workers engaged in scrap yards around the world are least or to best not exposed to potentially deadly hazardous materials.

Waste which says of its uselessness preserves some usefulness in it. Recycling, reuse and or redesign creates some usefulness and in turn can reduce waste which will be responsible for decrease in waste. These waste materials find place for getting disposed off in landfills. Reduction of waste generation will increase availability of raw material supply and save use of available virgin raw material. From ages in general and currently in particular few mechanisms, methods and technology are currently available to reduce or capture a product's intrinsic end-of-life value.

We have many items for consideration but one which is most vernable and finding place is the Plastic. Let us get in more details of this Plastic.

1.1. Plastics

In the carefree and easy going lifestyle this easy carrying and packaging material have invaded and is involved in nearly all aspect of daily life. There is no doubt that it provides myriad benefits, and is ubiquitous in consumer and industrial products. Like many more man made products plastics accounts for a large portion which turns in solid waste stream: On consideration of volume wise it accounts to 26 % and if considered by weight it accounts for around 10 %. Ever since the evolution of this man made product inception i.e. from 1950, global consumption of plastic products has experienced an annual growth rate of 9% resulting to increasing to over million metric tons in 2011 by rough estimate of various studies including the European Plastic Manufacturers association[4]. Plastics to the extent of two-thirds are used as material for packaging durable and non-durable goods and once it reaches destination are disposed off after this maiden use. It is well known that the plastics are recycled and reused for many rounds and folds. Every time they get recycled lose some credibility and detoriation in quality. The quality gets degraded and ultimately loses its usability. This unusable plastic often gets to the fold of waste and finds place in landfills or get burnt causing loss to environment. This volume of waste plastic is around 20 % of the entire volume in circulation[3].

1.2. End-of-Life Pressures

Like many of the products which are bio-degradable, plastics do not biodegrade and remain in the environment for thousands of years if land filled. This calls for manufacturers and reusers increased pressure to ensure collection and responsible reuse, recycling and even disposal of their products at end-of-life i.e. when it becomes waste and does not remain fit for further processing. Government and other regulators regulation requiring certain industries to prevent improper disposal of their products are also concerns of the users and manufacturers. Pressure in form of vendor-supplier relationships can also be thought off particularly in scenario of some players being position to exert major impact on their supply chain. As an example of these giant companies like Walmart, a company which has implemented a sustainability goal of zero waste and has significant influence in the supply chain, has required vendors to redesign and reduce the amount of packaging that goes into their products can be seen as example[7]. Pressure from consumers, who are becoming increasingly environmentally conscious, friendly and tolerant, can influence manufacturers by demanding responsible practices or by basing purchasing decisions on a product's perceived "greenness." Consumer power in this area has been enhanced by the increased availability of information regarding "green" products, companies, practices, and lifestyles due to the growth of online and mobile information and market access.

II. ECOSYSTEM AND CURRENT CHALLENGES

The ecosystem is composed of a balanced environmental setup. The use materials for industrial production whether it is organic material / product or outcome of inorganic ones, it uses raw material derived from the resources. The extensive use of raw material will bring to a situation where one will be left with no or lesser materials. The sustainable use and extraction of resource materials from the wastes must be thought of. In this field the major roles for ecosystem study can be in terms of Manufacturers, Consumers and Industries involved in recycling. Each of the segments can be dealt with as follows-

2.1. Producers or Manufacturers

Every producer or manufacturer produces and markets it for the consumers. Once the product is in hand of consumers it becomes difficult to keep track of products once it is procured by the end user. In case of plastic industry it is difficult to distinguish among the types of plastics when they are found in a mixed lot of mixed-waste plastic. Source of the polymer and manufacturer of the product whether is virgin or of recycled is currently impossible to track. Basically in case of plastics while sorting and separation process, plastics are cleaned, washed and thrashed or ground or cut into small pieces. In this process the marking of product manufacturer and types of polymers used gets mixed and make the eliminating any identifying physical markings almost impossible. In turn the Manufacturers who might be interested in details of the end-of-life of their products are not able to identify and ascertain precisely how much of their product or similar product is made available for recycling or is going for dumping in the landfills.

2.3. End User or Consumers

Products ones floated in market, comes to the users and in cyclic process reaches the end user making the end of life user / consumers an integral part of the end-of-life of products. Every local regulating or administrative bodies which can be municipalities and local governments provide options for collection of such products for collections or dumping which may in turn reach for recycling and or land filling as alternatives. The manufacturers have also started options of extended user responsibility services as per mandate of the local authorities for collection of waste products by charging a minimal amount sometimes at time of purchase of the product itself. The end choice to make use of facilities extended by the local authorities lies on the consumer to make the decision for disposing off their items / products for recycle, landfill, or uncared and even sometimes illegally disposing of discarded products. The consumer market is largely dependent on consumer behavior so the provision by regulations may not result in proper collection of waste materials. Thus even if provisions are made available for recycling it may not result in favorable conditions for items proper sorting and recycling. In case of re-improvement and re-adding of values for elongation of use of products it may involve collection, transportation to industry or servicing centre, cleaning and separating materials takes additional initiatives and value addition which will take considerable time and effort. This involved time will leave no option but to go for alternative product to meet the daily requirements at hand. The money involved in value addition may which may increase efficacy of product may not be appropriate to the extent and will be retarding factor for such initiative. The market with multiple options and increasing purchase value of consumer are another factor of concern.

2.3. Recycling Organizations

Currently the value addition and recycling efforts are being carried out in separate industries which are local and side units. The recycling industry is highly fragmented and often based on popularly known jugad technology. There is no or limited transparency in the quality and price of recyclables is at will of persons involved in it which often depends on the urgency and paying capacity of the end user. It is often in the raddiwala or scrap dealer market place which can be termed

as highly disaggregated marketplace, with thousands of unskilled or little skilled players involving multilayer transactional middlemen, leading to significant inefficiencies and loss of faith. The raddiwala or scrap dealers are often the recyclable buyers thus the quality, quantity and price can be inconsistent from source of shipments to persons involved in the shipment. Unfortunately individual sellers with least backing of particular industry meanwhile carry the liability for their shipments. Once the shipment reaches the buyer, he determines that the quality and as per his need and requirement may declare that items does not match the seller's description resulting in very less pricing or even may choose not to pay. In this case the seller either have to bear the loss or seek alternate for selling which makes the involvement volatile and highly risky. This lack of consistency in quantity , quality ,infrastructure, information sharing and transparency in the recycling industry results in the high risk and results in cheating and all tactics playing which costs adversely in doing business. [10]

III. NANOTECHNOLOGY AND RECYCLING

The accepted know how of Nanotechnology popularly known as "nanotech" is manipulation of matter on an atomic, molecular, and super molecular scale. Nanotechnology has been a topic of intense activity in the scientific community over the past few decades. Any material or matter on the atomic and molecular scale which comes in the range of 1 to 100 nanometers is referred to Nanotechnology Research efforts to describe, simulate, design or manipulate and control matter of such extremely sensitive and small particles led to the discovery of various special and unique optical, mechanical, electrical, magnetic, and other properties that are not typically present in bulk matter. In almost all spheres namely biomaterials, catalysts, cosmetics, electronics, energy storage, production, medicine, or whatever we name as field of application of specialization are among the potential applications on which nanotechnology have an impact and are in intensive research. This continued research topic which have imminence in the going of mankind in almost all sphere of life growth and interest in nanotechnology and nano-science has driven many researchers groups to put their efforts to discover in increasing number of applications relevant to improving the quality of life for humankind and make life easier and prosperous.

Often one can notice that the sorting and separation mechanisms for the nearing end to life products fir for recycling are tedious, expensive, inefficient and time consuming. The newer available operation research techniques for such efforts like tagging, tracking , extended producer responsibility (EPR) and other methods which indicates that after what duration and timing and detoriation these are to sent for recycling for improvement in efficiencies are not applicable for different reasons. During the life time the products keep changing among hands of users and in between these tags get displaced and such efforts are lost. The newer technologies like nano technology adds the tagging system which is invisible and will automatically remind the necessities and steps irrespective of the hands they keep changing for recycling and intermediate efficiency improvement steps at door steps or at factory points. Here the nano scale materials, structures, programs and effective steps can be utilized as "tags" which directly may be incorporated into or onto the product during production / manufacturing process. These methodologies are invisible to the naked eyes and never get removed by sustained use by different groups. These nano scale materials tagging systems are robust and effective and of state of art.

3.2. Exemplary Uses of Nanotechnology for Recyclable Tagging and Tracking

Nano materials, nanostructures using nanotech can be viewed as upcoming appropriate technology in tagging, tracking and identifying growth and stages of nearness of end of life state of products across complete life time of product. Application and extensive use of typical such initiatives have been reported in various articles of the scholars. Number of such technologies and materials have found the patent certification also worldwide The article by Pradeep and Sajanlal explain the technologies for inorganic or metal nano materials which can be fine tuned by changing size & shape of existing nano material for obtaining unique Raman, fluorescence, infrared optical or other required properties by incorporating additional chemical molecules/ions/species in the existing available nano-materials to get additional fine tuned applicable surface and properties.[2] The available unique optical signatures of these developed nano materials and their small sizes makes them adaptable and usable for use for tags to track a product where about and conditions throughout its lifecycle. In the article by Hong, methods for utilizing developed carbon nano-tubes, nano-wires, and nano materials for creating multilayered nanostructures and patterns for identification of such products. Use of these nano-materials and nanostructures on plastics, electronics, and other consumer items as nano-sized physical tags with unique property signatures can result in the useful application. Removal of these nano-sized tag is not possible. These nano tags can be interrogated using various optical, electronic, and magnetic detection methods at given points by appropriate devices during the entire lifecycle of these identified products for proper and authenticated manner for easy tracking.

Products entering the stage of reuse, recycle or getting near to the end of life i.e. waste stream at their end-of-life can be effectively separated and sorted by these effectively employed different identifying tracking and tag systems used by particular product including the chemical ones by the manufacturers helping in minimization of further wear and tear so that reuse capacity can be improved beforehand. This in turn will minimize and reduce the amount of potential recoverable and recyclable waste which will end finally in dumps of the non-degradable plastics landfills. Nano-sized

tags and trackers use will enable the documentation provisions of chemical and product to the manufacturers which can be used as tools for the regulatory bodies' requirement for adherence to the norms.
Impact of growth and application of nanotechnology on improving quality of life through extensive applications in areas of health, energy, environment, ecology and other emerging areas of growth for sustainable development is of on-going interest and subject of debate in the scientific research and development community. To cater the legal needs and for controlled development the regulating agencies need to come with standard norms and regulations for the development of nanotech and nano science for nano materials and nano structures.

IV. INFRASTRUCTURE

4.1. Recycling Exchange

Till now it is clear that plastics which are mostly used for packaging and other industrial uses supports the provision of tagging and tracking by suitable use of nanotech. As materials like plastic retain value even after disposal, identifying the stages in intermittent levels when they are nearing end of their useful life can benefit all users and stakeholders in maintaining and reenergizing the efficiency and possible improvement in the product's lifecycle. The EPR can play a vital role if extensively used. Other means of addressing or capturing this value is with the Recycling Exchange option, which acts as an end-of life trading platform for recycled materials may be of reduced value and importance. Such platforms and ideas can enable additional and secondary markets relating to recycling, such as insurance, shipping, logistics, sustainability rankings, and incentive platforms for growth of economy, industrialization and creation of job potentials.
The option and idea of setting up of Recycling Exchange can be technology amalgamation places and venues for marketing and place for data documentation and provider in all aspects related to recycling. This Recycling Exchange can serve as independent agency for verifier of recyclable and recycled materials, as well as a data consolidator, provider and financial engine that incentivizes manufacturers, producers, promoters, middleman agencies and consumers to close the loop on recyclables. In such particular model for trading scheme, materials are assigned credits based on a number of variables, such as material or commodity value, intrinsic energy value, whether and how many times the material has previously been recycled, and carbon value and technology used. Credits in the marketable and trading places can be used as tools and techniques for use as techniques for disposal which can be bought, sold, and traded, like any other tradable commodity or entity.[10]

4.2. Typical Example of Recycling Exchange Working: Lifecycle of a Pellet

The life cycle of (plastic) polyethylene terephthalate pellet (PET) development could be considered for demonstration of Recycling Exchange working during the life cycle of a product. Figure 1 show that complete life cycle of this. The blocks revolving around households are as follows:

1. Exploration and Production
2. Raw Material Manufacturing
3. Original Equipment Manufacturer (OEM)
4. Marketing chain
5. Collection and intermittent efficiency enhancement units
6. Recycling units

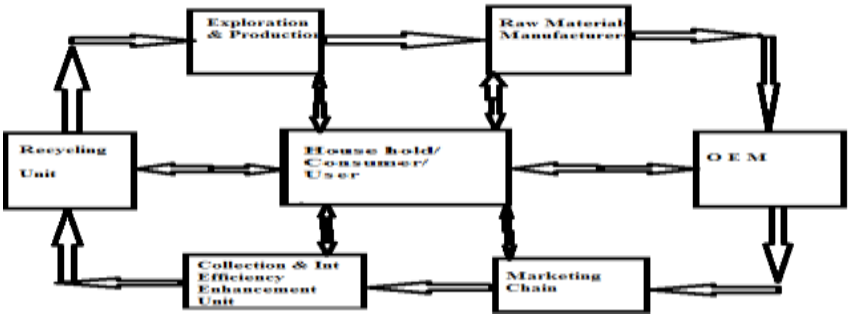

Figure 1. Life cycle of a PET Pellet

First stage is clear that the hydrocarbons are extracted from the underground reserve or from the bio based source.
In second stage the raw materials are sent to the raw material manufacturers who from pellets shape and sizes to the basic constituents. Here the nano science and nano materials technology for tagging and tracking embedding takes place. The

basic data of this tagging and tracking is forwarded to the Recycle Exchange for records and routine checkup and other system requirements and use. The central databank takes care of the life cycle and reminding the periodical requirements and instruction during the life cycle of the product.

Next comes the stage of Plastic pellets containing unique tags being sent to various Original Equipment Manufacturers (OEM) for incorporation into various consumer products. In this stage itself the tagged pellets are processed using extrusion, injection molding, blow molding, and other film molding techniques to form a product, which can range from plastic bottle, packaging material to casing of something to semiconductor industries and so on. The OEMs can incorporate additional unique nanotech tagging and tracking technologies into produces / products for improvement in the possible sorting and separation process if needed at later stage the plastics lifecycle. The modified and reentered specific details on the tags having further detail information about where about and other requirement details for product are again forwarded to the central record keeping Recycling Exchange for storing in the central database.

The finished products further find place through the marketing network to the actual consumer. All the information available from the tags and tracking system reaches to the consumer who can decode the information through technology means and gets all information and requirement of steps for further action which the OEM has forwarded. From time to time the OEM appointed agencies have to take the records from the data base of available system. The personals when scan the product information regarding the products location or other attributes are automatically traced and tracked and updation of data is maintained in the central database of the Recycling Exchange.

Once the product loses its usefulness it turns to the waste fold and here comes the role of recycling collection centers. The details are obtained from the tags and tracking system provided with the product. As per preset provisions end user or consumer may be entitled to receive some financial incentive as promotion and changing behavioral discourse for placing the product in the appropriate recycling container reducing the loss of possible retrieval of resource material and saving in terms of extractable useful items from the waste in the most technological and scientific ways. In process of extraction of materials and items the tags and tracking system identification tags and tracking facilities that were embedded into or onto the product may be authenticated and separated out and binned for a subsequent recycling step at the recycling units. This information collected and forwarded to the Recycling Exchange to verify and match the information on the database regarding the product is done for updating records and completing the life cycle of the product.

Thus in this manner, the incorporated unique tags and tracking systems possible through nanotech can allow each manufacturer to confirm the quality, quantity and details of their products that ends up in recycling process or even otherwise after say some considerable time if the expected life has expired and no data has been collected from either end till considerable time forcing the manufacturer marking the end of the product in circulation.

Always it will be easier for the pre-sorted tagged products to go for proper cleaning, crushing, and flaking as per requirement and pre-stated requirement. IN case of certain plastics, the flaked material may be chemically broken down and recovered for recovery of materials and once again put in use by sending these materials to the manufacturer or OEM to be reused into the same or new products.

V. BENEFITS TO STAKEHOLDERS

Keeping in mind the above discussion, it becomes easy to say that nanotechnology offers novel solutions for facilitating data and information through central database for need and steps for recycling by differentiating fungible materials and making end-of-life transactions more efficient. New nano-scale materials represent an ideal approach for keeping track of product and its state and condition of being in use thorough database irrespective of its place it is placed and always attracts the ignorance of the user because they are either ignorant of or have no idea about the tagging and tracking systems embodied on it making it possible for not being altered. The tags and tracking systems are not visible to the naked eyes.

The Recycling Exchange can serve as platform through which nano-materials can be tracked throughout its life cycle and appropriate record keeping of the products about its stage, status and state. Further it provides its usefulness even in case it loses its credential and comes to end of life marking it waste. The value for which the product has been left even it has turned waste is the residual benefit in terms of financial buyback to consumer individual and valued raw material and possible resource for the manufacturer once he gets it back for recycling or even disposal. Apart from the above mentioned benefits other benefits of stakeholders can be listed as below:

a. Proper identification of left out values of the materials and identification of liability materials in the wastes.
b. EPR mitigation costs for producers manufacturers at a product's recycling stage and even at end-of-life i.e. waste stage.
c. Exact valuation of amount of refinement required at recycling stage at the Recycling Exchange.
d. Higher value in recycled applications through tags and tracking systems verification of a material's history.
e. Retrieval of usable materials from the waste enabling development of new and higher value uses of end-of-life materials.
f. Resource optimal utilization and smart and just designing keeping environment and ecology in mind.

g. Production of environmental friendly produces and products
h. Development of faith and better resource and up keeping of products through improved brand recognition/customer loyalty for participating companies.
i. System record keeping, central database record keeping and better regulations in effective transparent and efficient manner and handling in markets.
j. Considerable reduction in waste through increased recycling, thereby benefitting the environment and society.
k. Availability of resource materials for more production and improved market access.
l. Generation of new skills and employment in organized and otherwise sectors.

VI. COCNLUSION

With advancement in technology and research activities and expansion of processing avenues big things and novel ideas are getting used and employed in the nano-sized has started. Coupling of nano-science, nano-materials and development of nanotech with a Recycling Exchange concept can help catalyze the shift to tendency of economy where even wastes will start fetching financial incentives and lead the system to nearing zero or at least minimal waste economy approach. It is going to provide an arena where all stake holders will be benefited and the growth will be environmental and ecological friendly.

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