A Brief Review on Biomass Converted Useful Materials

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Abstract In this work we have discussed the different types of biomass converted materials like pyrolysis of biomass, biomass-waste, gasification of harmful gases, carbon-based supercapacitor, silica, macadamia shell waste, lithium-sulfur battery, and rice husk, etc. from the different industries and different types of conversion approaches. There are different types of conversion techniques available for biomass conversion like CVD, hydrothermal process, thermolysis, pyrolysis, combustion, and chemical treatments. The aim of this study to identify the various types of biomass converted materials from different types of industrial waste and also find out the better way to convert into a useful material.

Keywords- Graphene, Waste, Bio precursors, Biomass, Glucose, Rice husk, Hemp

1. INTRODUCTION

Nowadays, industrial waste is the fastest growing waste stream, and one of the most technically challenging for resource recovery given the complex mix of precious and semi-precious and strategic metals, plastics, glass, toxic elements, and contaminants. Previously industries are majorly responsible for atmospheric and water pollution. Apart from that, now industrial waste is also responsible for atmospheric pollution directly or indirectly. There are different types of industries are responsible for producing different types of waste material that cannot be easily recycled. For example, automobile, medical, electrical, electronics, agriculture, and petrochemical industries are responsible for the production of various types of waste materials [1].

However, waste management is the only way to overcome this problem. This is the time to identify the different types of waste material from the different industries that we can easily recycle by the different recycling approaches. There are different types of recycling techniques available for recycling waste material. The types of recycling techniques depend upon the behavior of the waste material. Now, we are discussing the biomass converted materials. There are different types of biomass converted materials that can be easily converted into useful material. So, we need to identify these types of materials from the different types of waste material that can be easily recycled by the different recycling technique.

2. LITERATURE SURVEY

Here, we are discussing the different types of biomass converted material and different types of recycling processes. Zhou et al., have reported that microwave-assisted pyrolysis of biomass by using ZSM-5 composite catalyst supported by SiC foam. After facing a bunch of issues pertaining to the application of the catalyst in a catalytic fast pyrolysis system, SiC foam supports coated with the composite catalyst of ZSM-5 was developed and further, it is tested for up-gradiation of pyrolytic vapors in ex-situ catalytic reaction. During the study it has been observed that using the composite catalyst over the various configuration of catalysts placement, there is a significant improvement in the quality of bio-oil and this is achieved without compromising the yield. Further, they studied the bio-oil composition and product yields for various catalysts to biomass ratio values and concluded that there is a direct relationship between the catalyst to biomass ratio and bio-oil quality at the rate of its yield. This means, with the increase in catalyst to biomass ratio there is a significant increase in the quality of bio-oil and also its yield. But after the value of catalyst to biomass ratio reaches 1/10, the catalyst activity of composite catalyst starts declining. Anyhow the composite catalyst can be reused after regeneration and even after seven reaction-regeneration cycles, its catalytic activity was well...
However, the production process of carbon nanotubes from mixture carbon gas containing CO and CH$_4$ which were primarily obtained from biomass gasification gas or biomass pyrolysis, and is carried out in a fluidized bed and thermogravimetric reactor. Since the gas product i.e., the mixture gas has a very high carbon source, it can be used to synthesize CNTs. During this process, the decomposition of mixture gas results was compared with the results of the CO disproportionation process and pure CH$_4$ decomposition process by considering reaction temperature and partial pressure as parameters. After a series of experimentation it has been noted that with the increase in partial pressure ratio of CO/CH$_4$ value is 2. The carbon weight gain yield was 8 folds more than that of CH$_4$ decomposition under the same partial pressure. Further, the thermogravimetric results showed that there is an increase in carbon weight gain under the low temperature of CO/CH$_4$ gas mixture than the decomposition of pure CH$_4$ and also with the increase in CO partial pressure, the final carbon weight gain was enhanced. Specifically, at 550°C the carbon weight gain was enhanced by 5 times in mixture than in the pure gas. It was clear that in CO/CH$_4$ decomposition process, both CH$_4$ and CO with molecular hydrogen (H$_2$) as the medium played a coadjuvant role in promoting the decomposition reaction for each other. As a result, the carbon nanotubes (CNTs) produced were well graphitized, smoother and longer compared to that of pure CO and CH$_4$ gas decomposition. So, it is feasible to synthesize carbon nanotubes (CNTs) using CO/CH$_4$ mixture gas [3].

Moreover, Abbas et al., have discussed graphene quantum dots (GQDs) synthesis techniques from biomass-waste and also its immense applications in various fields. Due to the humongous increase in population, there is an increase in customer needs which in turn led to environmental deterioration and energy crisis. As a result, scientists started researching green routes to produce advance materials using renewable resources. Apart from various materials that were explored, nanomaterials that were based on carbon especially graphene quantum dots (GQDs) attracted enormous attention due to its special properties like long life, high conductivity, good biocompatibility, extensive surface area, and mainly low toxicity. Graphene quantum dots can be fabricated using various techniques. These techniques are basically categorized into the bottom down approach and a top-down approach based on the reaction mechanism. In a bottom-up approach, small organic building blocks were assembled chemically and this helps in synthesizing graphene quantum dots through various reaction mechanisms involving intermolecular coupling or carbonization process. But these approaches are complicated and time-consuming. In the top-down approach, large sp$^2$ carbon domains are converted into smaller ones by adopting mechanical shearing or chemical oxidation (etching or cutting), which results in high yield Graphene quantum dots. These methods are time saving and simple. After synthesizing, numerous methods were used to obtain desired and defined properties of Graphene quantum dots. GQDs so formed has a variety of applications in the biomedical field, light-emitting diodes and, PL sensors. It also has various energy applications like in supercapacitors, batteries, photovoltaics, etc. and due to its tunable properties, GQDs have very vast application area.

Moreover, Wang et al., have demonstrated the synthesis of supercapacitors containing solid-state asymmetric carbon by using the concept of all-round utilization of biomass. The concept, all-round utilization of resources is mainly used to increase economic and environmental benefits. All the subassemblies which form a supercapacitor are
derived from orange peel using various techniques. With the help of a step carbonization process of natural orange peel, a monolithic porous carbon (OPHPC) is prepared. The OPHPC obtained has a large surface area of 860 m$^2$g$^{-1}$ and it is naturally doped with 1.2% of nitrogen. Further, by using a simple hydrothermal process, the composite electrode is synthesized and it contains MnO$_2$ in major proportion. Due to its high porosity (74.6%) and natural porous channel structure, orange peel serves as a good material for a separator. And the electrolyte needed for a supercapacitor is obtained from orange peel juice since it has the best retention property in the natural separator. Due to the flexibility/plasticity of orange peel, the electrode shape can be customized. The ultimate supercapacitor obtained by combining all these components has a high areal capacitance. This method of synthesis not only uses the natural structure and inherent chemical components of biomass but also utilized the biomass inherent properties like flexibility or plasticity. This gives a positive hope in utilizing the biomass resources to its fullest [5].

However, the fabrication process of silver nanoparticles (AgNP/SiO$_2$) by using silica rice husk, uneconomical biomass as support via a template-free, novel, and facile sol-gel route. By introducing the acid metal solution into sodium silicate, silver nanoparticles were formed with a diameter of 25 nm on average and this is carried out at room temperature. The synthesized nanoscale silver particles were analyzed using various spectroscopic techniques and the following observations were evident. Silver inclusion into the framework of silica was found successful from EDX and FTIR analysis. From X-ray powder diffraction analysis, it was confirmed that in AgNP/SiO$_2$ amorphous nature of silica is preserved. From N$_2$ adsorption-desorption studies, it was evident that AgNP/SiO$_2$ exhibits high mesoporosity. From TEM analysis, it was observed that spherical silver nanoparticles were well dispersed in the silica framework. Also, the synthesized AgNP/SiO$_2$ has a Brunauer-Emmett-Teller surface area of 514 m$^2$g$^{-1}$ and it has a uniform pore size of pore volume 0.50 CCG$^{-1}$. This green technology used, is a promising technique in synthesizing uniform silver nanoparticles from biomass particularly agro waste [6].

Moreover, Noushad et al., have demonstrated the synthesis technique of Nanohybrid silica composite using inexpensive rice husk. These spherical Nanohybrid particles were used as fillers in the dental composite. It has a low specific surface area of about 30 m$^2$g$^{-1}$ and was extracted via a facile precipitation method by using chemicals that are basically non-toxic in nature. Two filler/matrix ratios, Composite A: 40/60 and Composite B: 50/50 were fabricated and tests were conducted between these two experimental dental composites. The result of the tests showed that dental composite B exhibits a flexural modulus of 6.2 GPa, Vickers’ hardness of 39 HV1, flexure strength of 107 MPa, the surface roughness of 0.057 Ra and compressive strength of 191 MPa. The above promising results direct us to use silica (which was basically extracted from rice husk) as a filler material in Nanohybrid dental composites [7].

WenLi Zhang et al., have proposed a salient method to produce hierarchical porous carbon with angstrom-sized high-volume pores by utilizing biomass. This porous carbon with angstrom-sized pores has potential applications in supercapacitors because of their characteristics like high specific capacitance along with high pack density. Here onion is considered as the typical biomass which acts as the carbon precursor. Cellulose, lignin, and hemicellulose are the typical components in onion. Lignin-potassium-salts/cellulose composite is formed when the chemical bond between cellulose molecules breaks and this reaction takes place when the onion is etched by KOH solution. The formation of onion derived porous carbon (OPC) occurs when the composite as-prepared undergoes pyrolysis in an N2 atmosphere. During the carbonization process potassium sites of lignin, potassium salts act as activation agents known as porogen. N2 adsorption/desorption and scanning electron microscope were used to study morphology as well as the porous structure of the onion derived porous carbon. By conducting electrochemical impedance spectroscopy, galvanostatic charge-discharge and cyclic voltammetry performance characteristics, if onion derived porous carbon for supercapacitor applications, can be noted down. Good cycling stability and high specific capacitance are the dominant characteristics seen when OPC is used as electrode material in supercapacitors [8].

Samane Maroufi et al., have demonstrated the means of utilizing waste materials to produce silicon fibers/particles economically in a more efficient way. The carbothermal reduction process was adopted for the synthesis of high-grade silicon carbide using waste materials. The two waste materials used here are e-waste glass (EWG) and waste tyre rubber (WTR) where both of them are referred to as high volume global waste streams and problematic. EWG is the source of SiO2. After the processing of these two materials for the synthesis of SiC by carbothermal reduction technique for a duration of 150 minutes at 1550oC, the resultant composite material consisted of a mixture of nanofibres as well as distributed nanoparticles. Nanofibres of length up to 5 microns and diameter varying from 10-150 nm were present. Also, nanoparticles with higher particle surface area (85.1-67.3 m$^2$g$^{-1}$) and size of particle ranging from 30-40 nm along with micropores of dominant pore size lesser than 2 nm. The reaction in the
gas phase between SiO and CO resulted in the nucleation of Silicon carbide nanofibre and later formation of Silicon carbide nanofibre. Due to the deposition of SiO on the nanoparticles of carbon derived from waste tyre rubber, the formation of Silicon carbide nanoparticles was achieved. Usually, the production of SiC nanomaterials is costlier and this can be replaced by synthesizing SiC nanomaterials cost-effectively by utilizing waste materials as mentioned above [9].

Yunyi Wang et al., have studied the synthesis of Biomass-derived novel carbons (BDNCs) along with its function. Also, parameters like the electrochemical effect of structural diversity, porosity and surface heteroatom doping of the carbons in lithium-sulfur batteries have been discussed. Biomass, which is one of the major sources of carbon is the prime factor for the genesis of fossil fuels. Contribution of nature to biomass is viewed as biomass with different microstructures including a set of pores namely micropores, hierarchical pores or mesopores. Biomass-derived novel carbons (BDNCs) exhibit salient characteristics such as eco-friendly nature, changeable physical/chemical properties and economical. Biomass finds its typical applications in energy storage devices, particularly in lithium-sulfur (Li-S) batteries. Analysis of market demands of BDNCs for lithium-sulfur batteries is carried out by comparing the lithium-sulfur batteries with lithium-ion batteries [10–12].

However, in biomass conversion, there is a wide usage of acid groups like SO3H which acts as a solid acid catalyst. The mesoporous carbon which is sulfonated has a high amount of these acid groups which can be accessed. Transportation of substrates and other products are helped by mesoporous. The stability of these materials is taken care of by its hydrophobic nature because conversion usually occurs in the water medium. There may be chances of helping in adsorption of reactants by few weak acid groups or exertion of catalytic function which is synergistic in nature. The maintenance of mesoporous in harsh conditions becomes much easier when silica phase co-exists. The hybrid surface provides specific polarity in addition to the potentiality for the purpose of multi-functionalization. Producing this mesoporous carbon from the initial stage is discussed in detail along with the application it provides in esterification and furan-derivative conversion. The problems related to stability have been taken care of and finally, an outlook into the future prospects of these materials is presented [13].

By using camphor leaves that are dead, graphene can be obtained which does not affect the environment and can be obtained by a simple and economical method called one-step pyrolysis. Atmospheric nitrogen which is in under flowing condition along with dead leaves of camphor at a high temperature of about 1200°C and that too at the rate of 10°C/min and then once the heating is done its temperature was brought down to the temperature of a room by making sure that there are no external hindrances. Some of the layers of graphene and end pyrolytic components were separated with the help of centrifugation and also by bringing in contact with P-Tyrosine using pi-pi interaction. The gradual degradation of camphor leaves especially at a temperature less than 800°C is observed by using TGA. Different tests like BET, TEM, etc among others were conducted for understanding the properties of graphene. The result shows about seven layers of graphene on an average [14].

It is essential to understand the spectral characteristics of electronic devices like sensors and also of opting electrical components in order to improve its usage in various fields. The sum-over-state method, as well as the tight-binding model, is employed. The absorption spectra which has linear polarizability along with twisted angle is first calculated. Initially, based on PPP, the carbon nanotubes model is established. The position of carbon nanotubes is changed to a particular angle by positioning carbon atoms. As bond length changes calculation is done for the torsional structure model of nanotubes. The analysis is done by tabulating the absorption spectrum obtained for various twisted angles, the method of analysis is SOS. In the carbon nanotubes, significant changes are observed in spectra due to twisted angles. There is variation in a number of peaks of absorption as well as the position due to the torsional angle, but its effect on spectra is mostly at low frequency. The effect on absorption spectra is even more important when exact changes are made to twisted angles. This forms a blueprint on how to go about with the fabrication of carbon nanotubes which is used particularly in photonic devices. Photonic devices are used in various fields off late [15].

There are various problems in the use of catalysts in pyrolytic systems which have to be very fast. So taking this into account, coatings of a catalyst ZSM-5, which is a novel composite, on foam supports of SiC was developed and for improving the pyrolytic vapors tests were carried out. The arrangement of catalyst placement was varied each time for the purpose of comparison and it showed that the composite catalyst helped in enhancing the quality bio-oil significantly without much reduction in yields. By compensating on yield, the quality of bio-oil could be enhanced by adding more catalyst to biomass ratio. Till the biomass ratio reached of 1/10, the composite catalyst was able to
maintain its activation energy. One more important aspect of this catalyst is that it could be reproduced and used multiple times, also its properties and catalytic activity could be kept intact up to seven cycles [2].

Rice husk ashes are used in order to extract amorphous silica with two different varieties named as cateto and agulhinha. A thorough study was done on various parameters like optimum time, reaction, etc, for producing SiO2 which has good sustainability and should be clean when obtained from the rice husk ashes. Analysis of structures was done with the help of nitrogen adsorbing-desorbing isotherms. There was an increase of 11 and 12% in the amount of silica for the two varieties respectively. The rice husks under treatment in RHAs, silica was mostly or amorphous or powder form and the temperature revealed the same. 2h at 700°C was the ideal or perfect condition for calculating hysteresis of type H1 along with IV type of isotherm was observed. It also showed an excellent specific surface area. In the case of cateto, the percentage of extraction yield was found to be between 80 and 99 and for agulhinha, it varied from more than 83 and less than 97 percent [16].

Carbon materials, which are activated by nanostructures of biomass which are porous in nature, have garnered importance in areas that deal with energy storage. This is because not much is to be spent on these materials and they have good conducting properties and are also environment-friendly. By activation and carbonization, hierarchical carbon materials (porous in nature) are doped with nitrogen by using celery which acts as a biomass carbon precursor. Even polymerization is employed. Polyaniline composite material is synthesized by using the prepared activated carbon which is obtained from celery. This process is done by adopting wet-chemistry. Supercapacitors use the porous carbon material as the active electrode. A specific capacitance 402 F g^{-1} is shown by this material. Capacitance retention of about 97% is possible even after 1000 cycles. The excellent performance of the carbon material boosts its usage in supercapacitors [17].

3. RESULTS AND DISCUSSION

In this work we have discussed the different types of biomass converted materials like pyrolysis of biomass, biomass-waste, gasification of harmful gases, carbon-based supercapacitor, silica, macadamia shell waste, lithium-sulphur battery, and rice husk, etc. from the different industries and try to convert that material in to a useful materials by using different types of conversion approaches. There are different types of conversion techniques are available for biomass conversion like CVD, hydrothermal process, thermolysis, pyrolysis, combustion, and chemical treatments. Nowadays, waste material from different sources is the biggest challenge for the country and worldwide. These waste materials responsible for many dangerous diseases that cannot be cured easily. So to reduce the harmful effects from the waste material has to reduce, reuse and recycle the waste material [13,14].

4. CONCLUSIONS

In this work, we have discussed the different types of biomass converted materials and recycling approaches. Accordingly, we need to explore new recyclable materials from different types of industrial waste. Still, we need to explore a better way to recycle the different grades of industrial and domestic plastic waste because plastic waste is one of the dangerous waste for human beings and the atmosphere. Thereafter, rubber waste from different industries is also a major area to explore a better way of recycling. Recently, electronics technology produced different types of gadgets and human-friendly equipment that makes human life easy and simple. Apart from that, these equipment industries produced a huge amount of Electronics waste that is very harmful to human beings and atmospheric conditions. So, we need to explore the new and better way to recycle this kind of new and advanced kind of E-waste material.

Key finding and future scope

The key finding of this work to explore and identify the new biomass material that can be easily recycled into useful material. Because existing materials are responsible for the various types of pollutions and also harmful to human life and atmosphere. To save the environment and reduce the harmful effects of non-bio converted material we need to increase the use of biomass convertible materials in the industries and daily uses.

Acknowledgment

The manuscript is prepared by taking assistance from Accendere Knowledge Management Services Pvt. Ltd. We are thankful to them. We also express our gratitude to our teachers and mentor for guiding us throughout the work.
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