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Review Article

Review Study on Waste Tire as an Adsorbent to Remove Toxic Metals from Waste Water

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ABSTRACT

In this study a novel adsorbent of discarded tires with activated carbon nanocomposite was prepared for the removal of toxic metals from industrial wastewater. Removal of pollutants such as lead, Arsenic etc from wastewater can be easily accomplished by focussing on efficient adsorbent, such adsorbents must be waste generated in abundance, economic and greener for simple removal of pollutants in water. This work has encouraged by the fact that tires that are thrown away and eventually becomes a health hazard to the environment. Researchers have found that tires are a low-cost adsorbent and convenient to use for the sorption of metals by batch adsorption technique. Therefore, the main objective of the present review is to research nanocomposites, adsorbent materials obtained from waste tires and further applied for the removal of persistent and residual toxic pollutants (heavy metals).

1. Introduction

In the recent era, fast moving world has increased the growth of automobile industries which has boosted the production of tires which is considered to be the biggest problem for the generation of solid waste due to its large volume produced and durability. The disposal of tires waste involves expensive, dangerous transporting and storing facilities. Due to the expensive disposal of waste tires, they are sent to landfills or open dumps that raises a concern for the environmental pollution. The growing environmental needs and legal demands for the decontamination of wastewater have given importance to the use of adsorbents. Adsorption is one of the most versatile, feasible and widely used technique for the removal of toxic metals from wastewater. A wide variety of materials such as activated carbon, rice husk, chitosan etc are the low-cost adsorbents used for the removal of heavy metals. Discarded tires are one of the adsorbent that can be conveniently used for the removal of pollutants from wastewater and provide economical and effective technical support to the industrial wastewater treatment plants[1].

1.2 Discarded tires

Tires contain carbon black reinforced rubber. A typical tires composition consists of a complex mixture of elastomers, polyisoprene, polybutadiene, Styrene butadiene rubber and carbon black. Small amounts of other materials including extender oil, sulphur, zinc oxide and stearic acid are also the components of discarded tires[2]. Quantity of steel is generally about 15%, and it is important for the heavy truck tires. Natural degradation of rubber tire is a slow process, as crosslinks between rubber polymer chains makes it extremely difficult for biodegradation[3].

1.3 Activated Carbon

Activated Carbon is a form of carbon processed to have small, low volume pores that increases the surface area that is available for adsorption. It is widely used as adsorbents for the purification of liquid and gases. It has a good mechanical strength, high surface area, with good adsorption capacity. Commercial activated carbons have surface area is more than 400m^2/g.

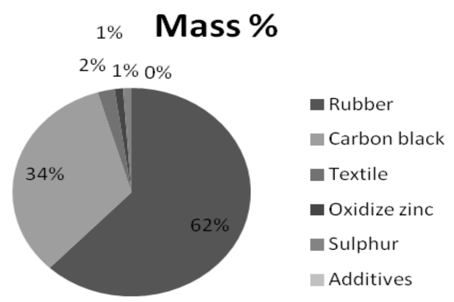

Figure No. 1: Shows the composition of discarded tires.

Figure No. 2: Represents Activated Carbon

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Many researchers have done the work on utilization of waste materials by using nano techniques and such nanocomposite have been found effective in adsorption of heavy metals ions like Cr, Pb, Zn, Sn, As etc. from waste water.

1.4 Development of Adsorbent from natural waste material

Many researchers reported the green synthesis of metal oxide nanoparticles (TiO_2, MgO, AgO) by using waste agriculture material such as Papaya Fruit extract, Pomegranate peels, and pomegranate juices and evaluated for their bactericidal or antimicrobial activities. They concluded that eco-friendly nanoparticles are bactericidal and wound healing can be used for pharmaceutical application and for sorption of heavy metals[4-9]. The antioxidant activity of pomegranate juices was evaluated with the presence of hydrolysable tannins present in the fruit rind that is account for the higher antioxidant activity. Synthesis of Chitosan-g-Biomass Ash/Graphene Oxide Nanocomposite was reported for the removal of Copper and Chromium from waste water with 69.5 % for Cu (II) and 74.7 % for Cr (VI) at pH 4.5 and 5 respectively[10]. Properties of biomass like heating value, moisture content, ash content, susceptibility to slagging and fouling and volatile content makes it a good fuel and appropriate modification of biomass ash with chitosan nanocomposite have been shown to effectively remove heavy metals from industrial wastewater. Guar gum nanocomposite will be used to adsorb heavy metal from the waste water stream. Due to its thickening, emulsifying, binding and gelling properties, quick solubility in cold water, wide pH stability, film forming ability it can be used as an adsorbent in the adsorption process[11-13]. Plants are a potential synthesizer for synthesis of nanocomposite[14, 15] and support a green synthesis of nanocomposite for removal of heavy metals from waste water[16-20].

1.5 Synthesis of nanocomposite with discarded tires

K.Keuseng et *al.*, 2005[21] prepared a Natural rubber nanocomposite with SiC nanoparticle and Single walled carbon nanotubes. Two nanocomposites were prepared SiC/NR and SWCNTs/NR and then Mechanical testing was done to get the modulus and strength of Natural Rubber, for understanding morphology nanocomposite was studied using SEM and Raman Spectroscopy.

Tangpasuthadol *et al*., 2008[22] synthesized silica reinforced natural rubber composite with the help of TEOS (Tetraethyl orthosilicate) to generate silica particles inside rubber. The silica particles dispersed evenly with sizes between 100 and500 nm, determined by Scanning electron microscopy (SEM). The mechanical properties were significantly affected by the addition of TEOS and 0.7% (w/w) of Ammonia was found sufficient for the conversion of TEOS to silica by sol-gel method. The addition of TESPT a coupling agent together with TEOS increased the hardness and the tear strength in situ silica-NR vulcanizates.

Atashbar *et al.*, 2018[23] synthesized magnetic $FeCuO_4$/rGO nanocomposite for the pyrolysis of waste tires and to convert them as an efficient fuel for the contaminants in wastewater and act as an adsorbent. The resulted activated carbon was used as a catalyst and mercury adsorbent. Accordingly, Mercury (II) removal was formulated by Langmuir and Freundlich isotherm models. Hence nanocomposite indicated the high efficiency.

Xiangwen Zhou *et al.*, 2010[24] prepared a styrene butadiene rubbe (SBR)/Carbon nanotube (CNT) nanocomposites by the combination of spray drying method and subsequent mechanical mixing process that is effective for enhancing the reinforcement effects of CNTs in rubbers. This work was developed for the modification and reinforcements on the polymers with large amount of CNTs in good dispersion.

Development of adsorbents from waste tires

Torrado *et al.*, 2011[25] developed the adsorbents with the scrap tires. Carbonaceous adsorbents were prepared by treatment of HCl, HNO_3, and NaOH aqueous solutions in N_2 atmosphere. Then, these adsorbents are characterized in terms of texture and tested as adsorbents of phenol, p-aminophenol, p-nitrophenol, of metals in aqueous solutions. The pyrolyzed product is a carbonaceous adsorbent that can be used for the removal of heavy metals such as mercury and lead from aqueous solution.

Dimpe *et al.*, 2015[26] aim was to prepare to prepare a chemically activated material that can be obtained from waste tires. The tire based activated carbon was applied for the adsorptive removal of Cu (II) and Pb (II) ions from wastewater collected from domestic WWTP. The prepared adsorbent was characterized by scanning electron microscopy. For optimization purposes, factors such as ph, contact time, mass of adsorbent and concentration of a solution were effectively studied.

The preparation of discarded tires derived activated carbon usually initialized by the pyrolysis of the rubber and is further go through controlled oxidation which is known as activation. San Mighuel *et al.*, 2002[27]. The general steps and procedures that are commonly used for the development of adsorbents by discarded tires are given in Figure: 3.

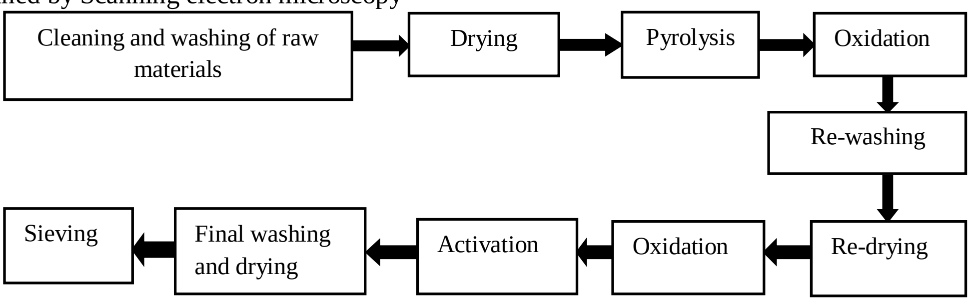

Figure No. 3: General Steps for the preparation of adsorbents from discarded tires.

1.6 Removal of toxic metals from waste tires

Batch Adsorption experiments were conducted for the removal of heavy metals from waste tires. This experiment is carried out to examine the adsorbent capacity of an adsorbent, temperature, contact time, pH and adsorbent dose on the adsorption process.

Mousavi *et al.*, 2010**[28]** main objective was to investigate the use of waste tire rubber ash as an adsorbent for the removal of Lead (Pb^{+2}) ion from an aqueous solution. Batch adsorption studies were carried out to study the effect of pH, temperature, and effect of contact time was studied. The removal of heavy metals by adsorbents depends on the pH of initial concentration. Batch equilibrium studies were carried out in different pH values.

Manchon-Vizuete *et al.*, 2005**[29]** used the rubber of waste tires to prepare carbanaceous products and these products were used as an adsorbent for the removal of mercury in aqueous solution. The adsorption of mercury has been studied from kinetics and equilibrium standpoints. This paper concludes that the adsorption capacity of tyre rubber towards mercury is increased when the adsorbent is successively heated and chemically treated. Knocke *et al.*, 1981**[30]** accesed the properties of waste tire rubber for the removing mercury solution. They find an alternate way to form a sulphur free rubber material by the sorption mechanism depicted in Figure 4. Research parameters included mercury concentration, sorbent particle size, solution temprature and hydrogen ion concentration.

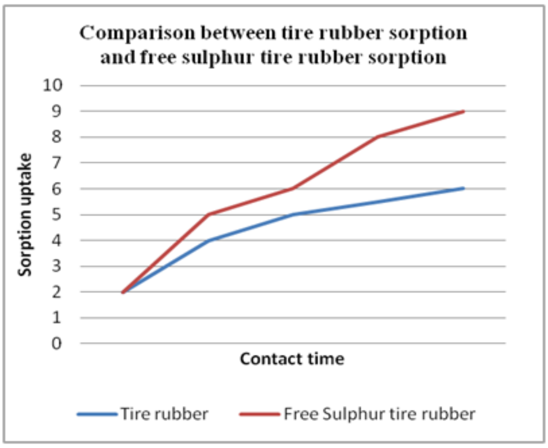

Figure No. 4: Research parameters included mercury concentration, sorbent particle size, solution temprature and hydrogen ion concentration.

Table No.1: Discarded tire adsorbent for the removal of heavy metals

Metal	Type of Adsorbent	Main findings and conclusions	References
Cd(II)	Finely grounded rubber tire	• Adsorption is based on the absence and presence of ultrasound. • Amount of sorption increases with increase in temperature in absence and presence of ultrasound. • Sorption efficiency increase with decrease in the particle diameter. • Contact time effects the removal of Cd (II). By only stirring sorption process was rapid for initial 40 min and then to equilibrium. In presence of ultrasound it was rapid for 15 min and then to equilibrium.	**[31]**
Arsenite As (III) and Arsenate As(V)	Waste tire rubber with cationic polymers, poly (3-acrylamidopropyl) trimethyl ammonium chloride (p(APTAMCl)).	• Various parameters by influencing As (III) and As (V) adsorption were optimized through batch adsorption, i.e. pH, contact time, concentration and temperature. • Amount of As adsorbed is found to be stronger at pH 4 to 9. • Concentration of APTAMCl polymer increases the amount of As adsorbed, and temperature might cause degradation of p(APTAMCl).	**[32]**

2. Conclusion

The current survey suggests the variety of preparation methods for the production of adsorbent materials that are obtained from waste discarded tires. The effective techniques have been suggested by the development of low-cost adsorbents and environment friendly techniques that can be applied for the removal of toxic organic and inorganic pollutants. This research is focussed on the automobile waste tires that is the topic of great importance. Activated carbanaceous adsorbent materials that are produced from discarded tires is found to be the efficient adsorbent for the removal of toxic metals from industrial wastewater. The study represents that there is a need to recycle, reuse and

convert these automobile tires to produce various adsorbents that can be further applied in an effective way.

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