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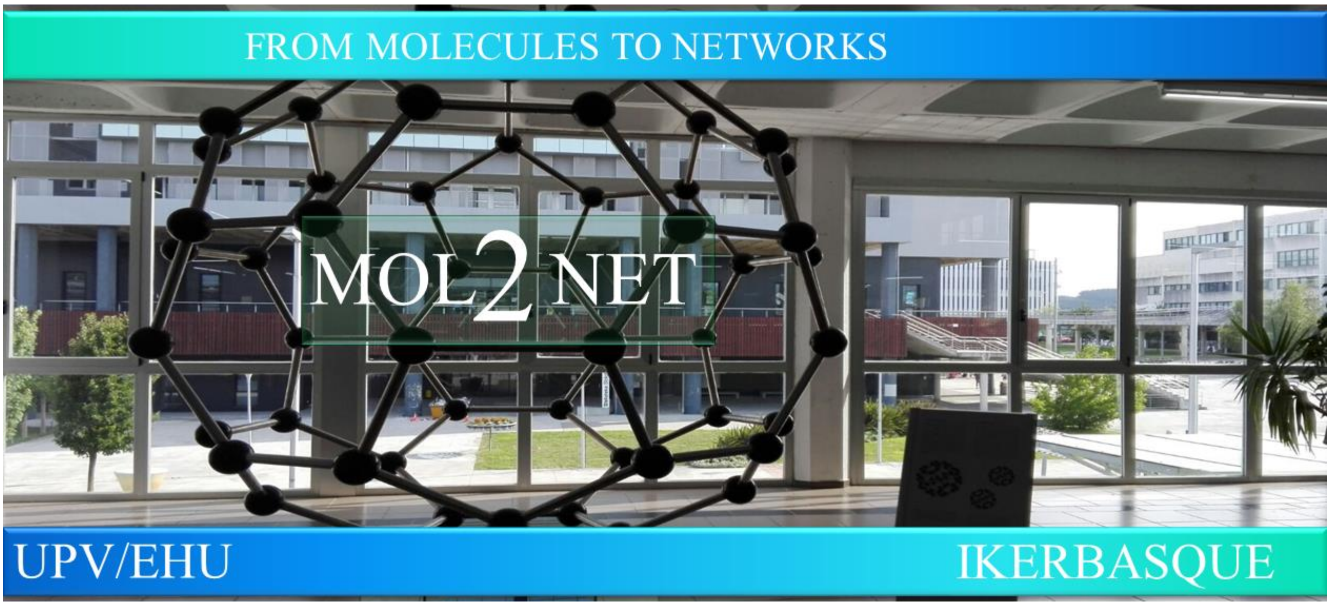

Use of low-cost green adsorbent for the simultaneous removal of toxic industrial dyes from the wastewater as sustainable solution to environmental remediation, part 1: material spectroscopic and physicochemical characterization

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Graphical Abstract

Abstract.
Over thousands of dyes are widely used in textile, chemical, paper, and pulp industries. These dyes are a major constituent of industrial effluent and are considered a major water pollutant. In the present study, coconut fiber has been explored for the simultaneous removal of toxic industrial dyes from their aqueous solutions. Coconut fiber is a commonly available low-cost bio-waste, which can be easily

processed as a potential absorbent for the abatement of water pollution. In this conference we preset 2 different but related communications (part 1, 2). Each communication will be presented in one different MOL2NET congress (NANOBIOMAT, and CATCHTOHIT).

In the first communication (part 1), coconut fiber was thoroughly washed, dried, and crushed into the powder form as adsorbents and has been analyzed for the functional groups, morphology, and zero point charge using Fourier Transform Infrared spectroscopy, field emission scanning electron microscopy, and pH measurements, respectively.

In the second communication (part 2), It was found that the adsorbent exhibits high % removal capacity of 96.25±0.001, 81.24±0.015 and 89.81±0.004 for methylene blue, rhodamine B, and crystal violet dye, respectively in the individual dye removal studies. The simultaneous removal of the mixture of MB, RhB, and CV with the adsorbent showed an efficiency of 81±0.005% in 60 minutes. The adsorption studies were optimized for pH and dosage. This open a door to study the potential of this material for development of industrial product by an small-medium sized (SME), start-up, or chemical company.

The findings of the study demonstrate the potential of coconut fibre as an abundant, low-cost, multifunctional adsorbent for the treatment of wastewater for a range of industrial and agricultural contaminants.

Keywords: *Industrial dyes; adsorption; coconut fibre; wastewater; heavy metal; green adsorbent*

Introduction

Biomass is the organic material obtained from the living organisms such as plants and animals. This biomass which gets converted into biowaste after their usage is not properly discarded. India generates 62 million tons of biowaste every year which is deposited off causing the pollution of land. The most common biomass material used includes wood, plant and animal waste. These are called biomass feedstock [1]. Biomass has many advantages like it is easily available in nature, has properties like regenerability, good adsorption capacity, selectivity and is also inexpensive [2]. Different types of biomass includes the orange peels, mausambi peels, coconut fibers, tea waste, groundnut shell, bark of the tree, dry leaves, sugarcane waste, rice or wheat straw, corn straw, etc. can be used as a biomass to treat the waste water[3]. For example in a study by Saravanan *et. al*., rice husk was taken as the biowaste and converted to biochar to remove basic red 09 (BR09) as well as blue 41 (BB41) dyes from the waste water [4]. In another study, Azardirachta Indica waste biomass was used to remove the bentazone toxic insecticide from the waste water [5]. Report on removal pharmaceuticals as well as the heavy metal from the waste water using Pisum sativum pods biowaste along with the starch hydrogel have been published by Mohammed *et al.* [6]. Similarly, many studies on different types of biomass being used for the removing different kind of pollutants from the environment are available.

In the present study, we selected coconut fiber (CF) as the biomass to treat the wastewater. CF has properties like easy availability, low-cost, porous structure and large surface area. CF has a high lignin content because of which it has property like elasticity and is also durable as well as resistant to rotting. Apart from lignin, it also has specific content of cellulose [7]. Coconut fiber is used as it also shows the potential of adsorption and treating the wastewater accordingly and it is a totally green process [8]. Thus, owing to these properties, coconut fiber can serve as a potential biomass for wastewater remediation.

Materials and methods

Separation of coconut fibers from coconut shells

The coconut shells/coir required in this study were collected from a local market in Ahmedabad, India. The coconut shells were separated into fibres and used for the study.

Pre-treatment of coconut fibres

The separated coconut fibres were washed with distilled water, after which they were dried under the shade. The fibres were then crushed and converted into powder form. The obtained powder was sieved with a 75µm sieve to obtain particles of uniform size. The particles were stored in air tight vials for further analysis to avoid moisture. The schematic for the entire process is shown in figure 1.

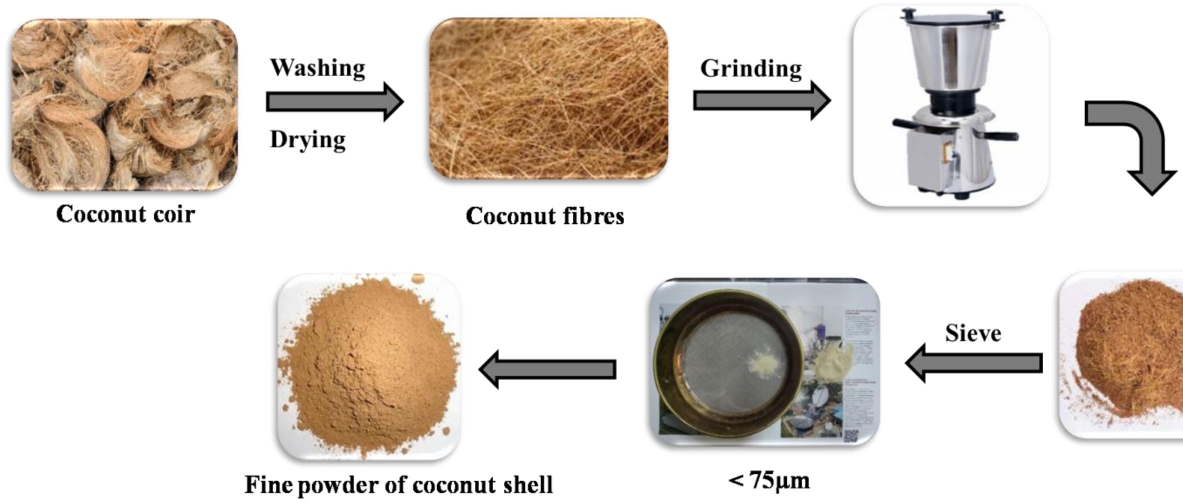

Figure 1: Scheme representing the step involved in the separation and pre-treatment of coconut fibre.

Characterization of the material

CF was analyzed for their morphology, functional groups, and point of zero charge by using different characterization techniques like Field Emission-Scanning Electron Microscopy (FE-SEM), Fourier-transform infrared spectroscopy (FT-IR), and pH measurements. The Fourier-transform infrared spectra of the samples were recorded using FT-IR spectrometer Perkin Elmer, spectrum 2 model in ATR mode in a scan range of 400 to 4000 cm-1. The FE-SEM images of the samples were taken in Zeiss ultra 55 model at acceleration voltage of 5.00 kV. For FE-SEM analysis the samples were sprinkled on clean aluminum stub over conducting carbon tape and with a thin gold layer using LEICA EM ACE200 to make them conductive. The Fourier-transform infrared spectra of the samples were recorded using FT-IR spectrometer Perkin Elmer, spectrum 2 model in ATR mode in a scan range of 400 to 4000 cm-1. For the point of zero charge measurements, aqueous solution of $NaNO_3$ was prepared. The solution was then adjusted to different pH ranging from 3 to 12. Fixed amount of CF was soaked in each solution with different pH. After the end of 24 hours, the change in pH of each solution was noted and a graph of pH versus Δ pH was plotted to estimate the point of zero charge.

Results and discussion

Morphological analysis from FE-SEM image of CF clearly shows the presence of fibrous shape morphology (figure 2a). The functional group analysis was done using FTIR spectroscopy which showed bands corresponding to various stretching and bending frequencies. In the IR spectrum of CF, the characteristic bands at 1750 and 1240 cm^{-1} are attributed to C=O stretching of lignin and hemicellulose and C–H, C–O stretching of cellulose. Other peaks at around 3400 cm^{-1} is assigned to –OH stretching, 1614 cm^{-1} is for C=C of lignin and 1440 cm^{-1} can be attributed to C–H vibration (figure 2b). From the point of zero charge (PZC) study, was the calculated PZC. This implies that at pH values less than CF exhibits a +ve charge on its surface while at pH value more than the surface has negative charge. At pH=PZC, no charge is present on the surface of CF (figure 2c).

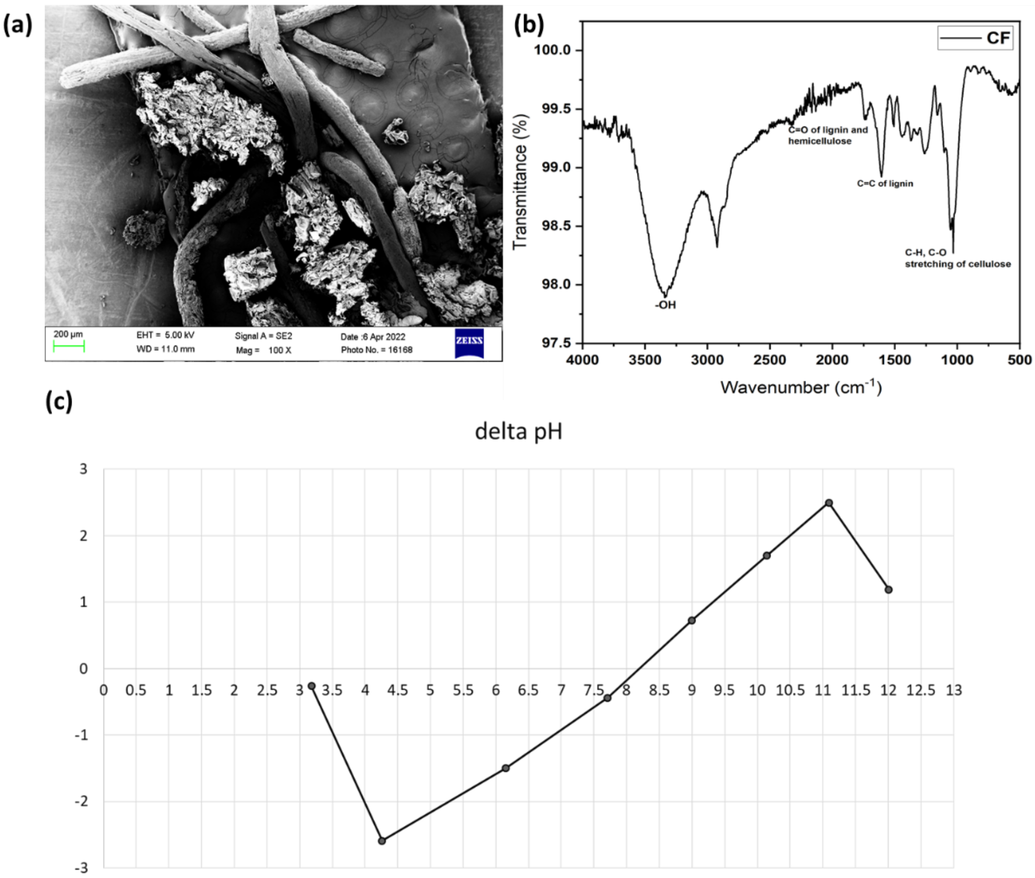

Figure 2: (a) FE-SEM image (b) FT-IR spectrum, and (c) point of zero charge of CF.

Conclusion

The coconut fibre waste was collected and processed to obtain coconut powder. The detailed characterization and analysis of coconut fibre shows linear porous structure and presence of organic functional groups. The zero point charge analysis points towards the negative surface charge of the coconut powder. The coconut powder due to the presence of porous morphology, presence of organic moieties and negative surface charge has potential to be explored as adsorbent for removal of toxic dyes especially cationic dyes**.**

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