Surface Modification of Activated Carbon to Treat Polluted Water Streams

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Introduction

Water pollution due to the industrial applications, agro chemicals, etc. is a serious environmental problem which creates health, economical, and ecological impacts worldwide. The presence of toxic compounds, both organic and inorganic, in water streams creates significant threats to man and nature. Therefore, polluted water streams should be purified before releasing to the environment (Akhtar *et al.*, 2006); (Massa *et al.*, 2004). Adsorption is one of the most versatile and effective method, among other different methods. Adsorption is a natural process by which molecules of a dissolved compound collect on and adhere to the surface of an adsorbent solid. Activated carbon has a great potential for effectively removing contaminants from water by adsorption process due to its electrochemical surface properties. Most forms of activated carbon are non-polar in nature, so they have the greatest affinity for other non-polar substances. As a result, they are most effective in the removal of a variety of organic contaminants. However, activated carbons do not effectively remove trace metals, contaminants of high solubility or inorganic salts like nitrates. Hence, modifying the surface chemistry of activated carbon becomes an attractive route towards novel applications in enhancing the efficiency in water treatment (Chen *et al.*, 2003). In this research, chemical treatment was used to modify the commercially available activated carbon and the modified material was characterized.

Methodology

Five grams of commercial activated carbon (Aldrich) and 50 ml of 1M acetic acid were stirred in magnetic stir plate at room temperature for 24 h. Then it was repeatedly washed with 50 ml of distilled water to obtain constant pH value. Finally, the modified activated carbon (MAC) sample was centrifuged (Beckman CP centrifuge) and dried at vacuum desiccator at 60 ^{0}C temperature for 4 h until get powdered.

Both parent activated carbon (PAC) and MAC were characterized using Fourier Transform Infrared Spectrometry (FTIR) (Nicolet 6700 FTIR), Zeta-Meter 4.0. (Zeta Meter Inc), pH of zero point charge (ZPC) and Methylene blue (MB) absorption measurements.

Results and discussion

Fourier Transform Infrared Spectrometry (FTIR) analysis:

Figure 1 shows four major peaks at 3465.3 cm^{-1}, 1635.3 cm^{-1}, 1384.5 cm^{-1}, 526.1 cm^{-1} of FTIR spectrum of original PAC. The broad and strong absorption peak at around 3465.3 cm^{-1} is O-H group and peak at 1384.5 cm^{-1} is O-H group which is derived from deformation modes of alcoholic and phenolic type O-H with a sterically hindered. The strong peak at around 1635.3 cm^{-1} appeared in spectra is the functional groups of C=O (Coates, 2000). The strong peak at around 526.1 cm^{-1} is also due to the simple hydroxyl compound. It is indicated ''free'' OH groups, either on the surface, or embedded within a crystal lattice, and free from interactions with other ions or groups (Coates, 2000). Figure 2 shows the FTIR spectrum of the modified activated carbon which is very similar to that of PAC. However, the strong peaks appeared in spectra of PAC is shifted in MAC indicating surface modification on activated carbon.

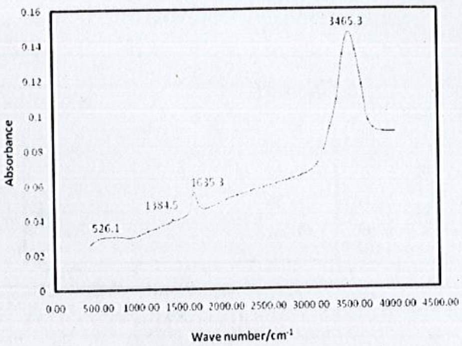

Figure 1: FTIR spectrum for parent

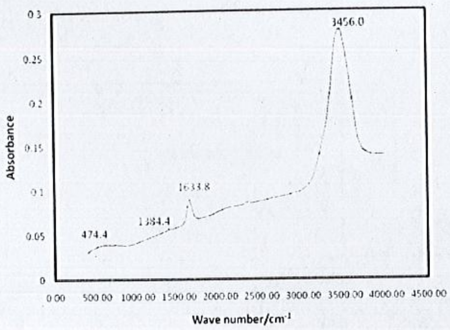

Figure 2: FTIR spectrum for modified activated carbon

Zeta-Meter 4.0. analysis:

At pH 7, Zeta potential of PAC and MAC were found to be -132.2 mV and -172.6 mV, respectively. Zeta potential was reduced by 35.4 mV after the surface modification. The results obtained have a good agreement with that of Thielbeer *et al.* (2011). Hence, zeta meter 4.0 analysis also confirms the surface modification of activated carbon.

pH of zero point charge:

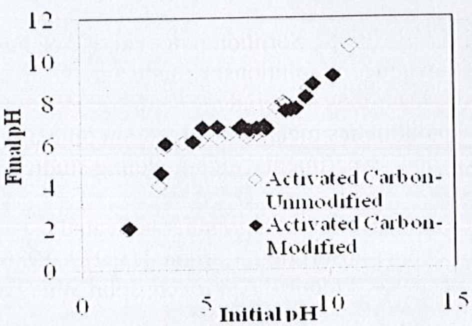

Figure 3: Determination of pH_{ZPC} of PAC and MAC without introducing ionic strength

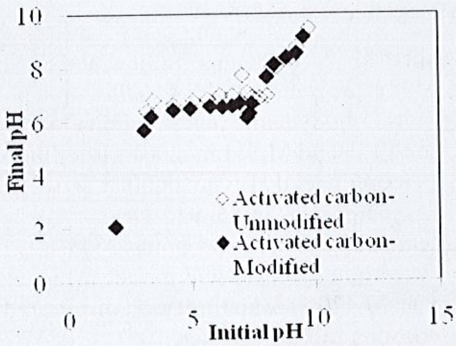

Figure 4: Determination of pH_{ZPC} of PAC and MAC with introducing ionic strength 0.05 M of $NaClO_4$ solution.

The pHzpc value of PAC was found as 6.9 and that of MAC was 6.7 without background ionic strength. Therefore, in MAC, at pH values greater than 6.7, the surface charge is negative. At pH values lower than 6.7, the surface charge is positive. Similar experiments were repeated by introducing ionic strength to the background electrolyte solution. The results show that ionic strength does not have a significant impact on the ZPC. The result of ZPC is in good agreement with that of Chen and Lin (2001).

Methylene blue absorption measurements:

Methylene blue (MB) method has been used to determine the surface area of activated carbon. Using Figure 5 and 6, the specific surface area of PAC and MAC were calculated as 188.87 m^2/g and 132.12 m^2/g, respectively. As such, after the modification the surface area was reduced. This could arise from pore blockage by adsorbed acetic acid molecules. This finding is consistent with the results reported elsewhere (Chen *et al.*, 2003).

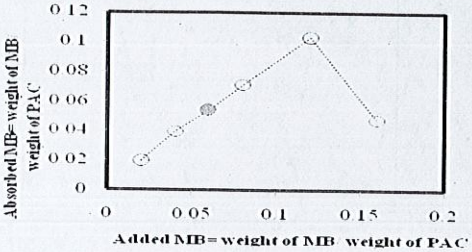

Figure 5: Determination of the point of complete replacement of cations from the titration curve of PAC.

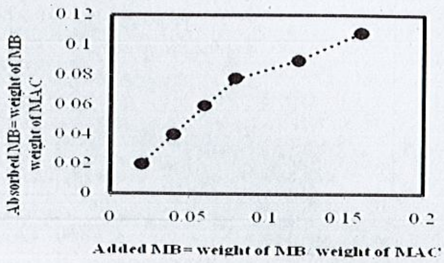

Figure 6: Determination of the point of complete replacement of cations from the titration curve of MAC.

Conclusions

Commercial activated carbon was chemically modified. Several characterization processes were used to investigate the surface properties of modified and unmodified materials. Investigations confirmed the occurrence of surface modification.

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