

Synthesis of a Mesoporous Sorbent for the Removal of Mercury Ions from Water

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Abstract: A mesoporous sorbent (MS), synthesized from fly ash, was modified in a variety of ways such as sulphidation and thiolization under different condition to obtained a modified mesoporous sorbent (MMS). MS, MMS, powder activated carbon (PAC) and rice husk (RH) were characterized for their various physicochemical characteristics. The sorptive capacity of these four sorbents MS, MMS, PAC and RH was evaluated in batch tests, the sorbents MS, MMS, PAC and RH could remove 83.5%, 86.9%, 85.7% & 50.2% mercury (ii) ions at metal concentration 10 mg/l, pH 6, temperature 25°C, agitation time 5h., sorbent dose 5g/l and rpm 150. The order of mercury removal capacities for these chemical sorbents was found to be MMS > PAC > MS > RH. Equilibrium was attained in 5h and the maximum removal was at pH 6. Thus acid medium favoured the removal. In the column process MS, MMS, PAC and RH could remove 63.1%, 68.7%, 67.1% and 28.8 % mercury (ii) ions at metal concentration 10 mg/l, pH 6, temperature 25°C, bed height 60 cm and flow rate 1ml/min. mercury showed the highest removal of 86.9% and 68.7% by batch and column process respectively.

Key words:

INTRODUCTION

Hg finds numerous applications. The larger consumer is the chloro-alkali industry which manufactures Cl_2 and NaOH by electrolysis using Hg electrodes. The second largest is the production of electrical apparatus, e.g., Hg vapour lamp, electrical switches, Hg batteries etc. the third largest consumption occurs in the agricultural industry employing a large number of fungicides for seed dressing. Pb, Cd and Hg are used in batteries. They enter environment particularly in to water sources due to their various applications and byproducts. Hg (0), Hg (I), Hg (II) and Cd (II) are retained less strongly by soils than the other toxic cations and hence pose a more serious problem. Hg (II) can be reduced to Hg (I) and more significantly to Hg(0) that is volatile and can diffuse as a gas through soil pores.

Thus Hg is most mobile toxic metal in soils. The desirable limit (DL) of Hg for drinking water is 0.001 ppm with no relaxation to any maximum permissible limit (MPL). Hg^{2+} and Hg^+ are toxic to brain and nerve. RHg^+ species are highly toxic and easily cross the biological membranes and harm foetus. In this way Hg continues to affect generations after generations [1]. Many materials have been tried for mercury removal from water [2, 3]. The present study has been undertaken to investigate and compare the suitability of mesoporous sorbent (MS),

modified mesoporous sorbent (MMS), powder activated carbon (PAC) and rice husk(RH) for mercury removal from waste water using batch and column experiments.

MATERIALS AND METHODS

A portion of dry powder of fly ash and 2.0 mol/dm³ NaOH solution were put into in autoclave at 1g/cm³ of solid liquid ratio. MS synthesis was carried out by an alkali hydrothermal treatment at agitation speed 500 rpm, temp.120°C and reaction time 3h (Murayma *et al.*, 2001). MS was functionalized through the covalent grafting of an organic ligand. Several ligand such as Dodecan-1- thiol (DT), 3mercapto-propyl trimethyloxysilane, Oxalic acid (OA), tartaric acid (TA) etc. were tried one by one depending on the previous results to get the best modifier. The crushed MS and MMS were palletized separately by injecting them in to a commercial pellet mill. Dry steam was used if the moisture content was low, but no other binder and additional were used.

MS, MMS, PAC and RH were analyzed for their physicochemical characteristics.

The stock Hg (II) solution was prepared by dissolving 1.080g of mercury (II) oxide, HgO , in a minimum volume of (1:1) HCl and then diluting it to 1Litre with double distilled water (DDW). Four standard solutions of 0.1, 1, 5 and 10 mg/l concentrations of Hg(II) were

prepared by diluting the stock solution of 1g/l. batch tests were conducted under steady and transient conditions at different initial mercury concentrations (0.1, 1, 5 and 10 mg/l), sorbent dose (0.1, 1, 5 and 10mg/lof toxic solution), contact times (1, 3, 5 and 24h), pH values (2, 4, 6 and 8) and temperatures (15, 20, 25 and 35°C). The contents were shaken at 150 rpm in a rotatory shaker, centrifuged at 2000 rpm for 10 min and the supernant liquid was filtered using a 0.45- μ m membrane filter. The filtrate was analysed for Hg²⁺ before and after sorption with the MHS system of a Perkin-Elmer AAnalyst 100 AAS. Experiments were triplicated and results averaged. Column tests were also conducted at using PVC column (100cm height \times 2.5 cm i.d.) bed heights (BHs of 10, 30, 60 and 75 cm), influent concentrations, pH values and flow rates (1, 3, 5 and 10 ml/min). Attempts were made to desorb toxics from the loaded sorbents using various molarities of HCl, HNO₃, NaOH and other chemicals. The regeneration cycle was repeated three times. After each cycle the sorbent was washed with distilled water and dried.

RESULTS AND DISCUSSION

Only 9 Figures of results⁴ are given below- Removal % of Hg of different concentration and at adsorbent dose 5 g/l, pH 6, temp. 25°C and rpm 150.

Removal % of Hg of different adsorbent dose and at concentration 10 mg/l, pH 6, temp. 25°C and rpm 150.

Removal % of Hg of different pH and at concentration 10mg/l, adsorbent dose 5 g/l, pH 6, temp. 25°C and rpm 150.

Removal % of Hg of different agitation time and at concentration 10 mg/l, sorbent dose 5 g/l, pH 6, temp. 25°C and rpm 150.

Removal % of Hg of different temperature and at concentration 10mg/l, sorbent dose 5 g/l, pH 6, contact time 5h and rpm 150.

Removal % of Hg of different conc. and at bed height (BH) 60 cm, pH 6, flow rate 1ml/min and temp. 25°C by column process.

Removal % of Hg of different pH values and at conc.10mg/l, bed height (BH) 60 cm, flow rate 1ml/min and temp. 25°C by column process.

Removal % of Hg of different BH and at conc.10mg/l, pH 6.0, flow rate 1ml/min and temp. 25°C by column process.

Removal % of Hg of different flow rates and at conc.10mg/l, BH 60cm, pH 6.0 and temp. 25°C by column process.

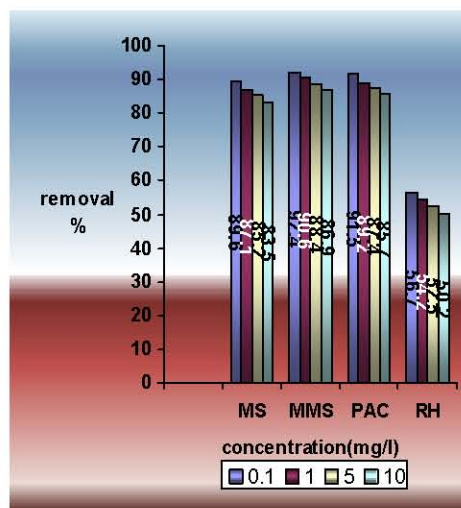


Fig. 1:

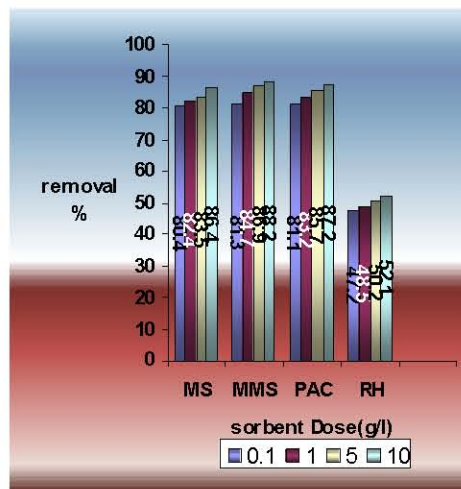


Fig. 2:

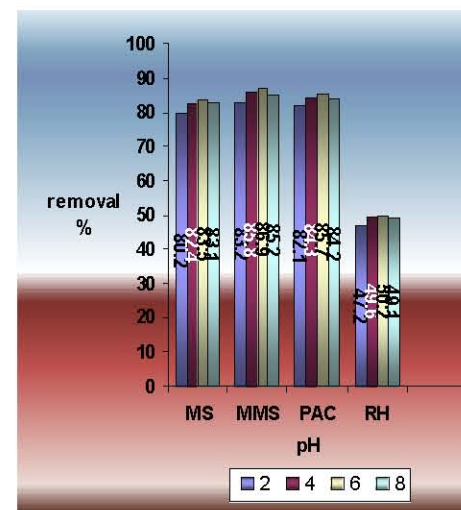


Fig. 3:

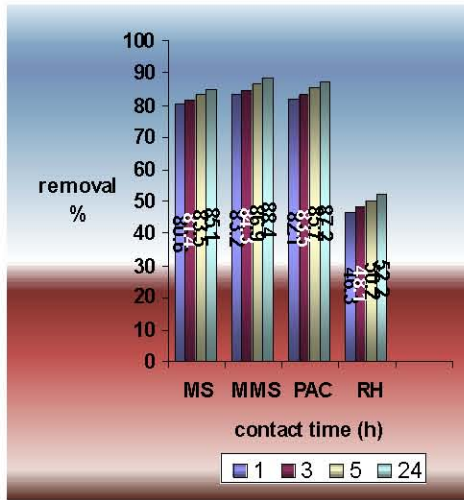


Fig. 4:

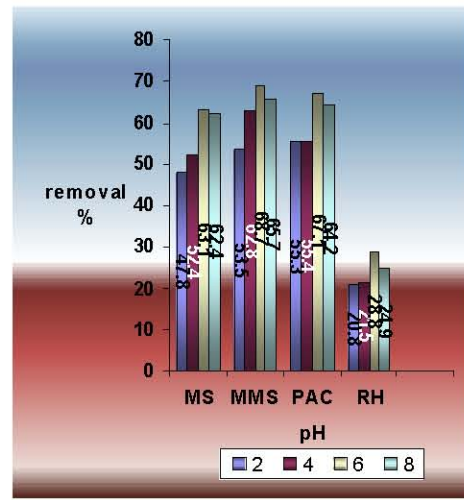


Fig. 7:

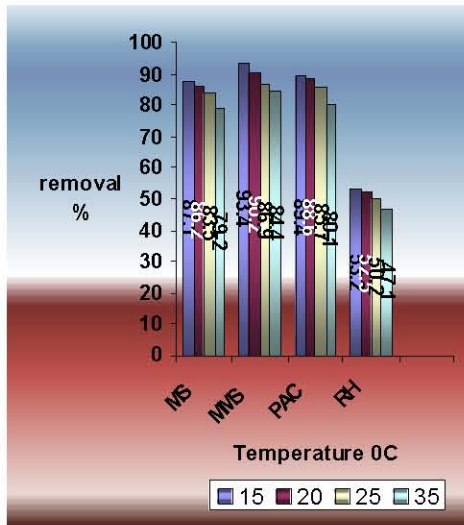


Fig. 5:

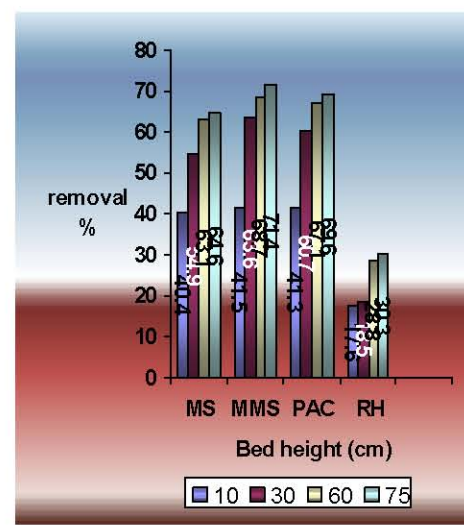


Fig. 8:

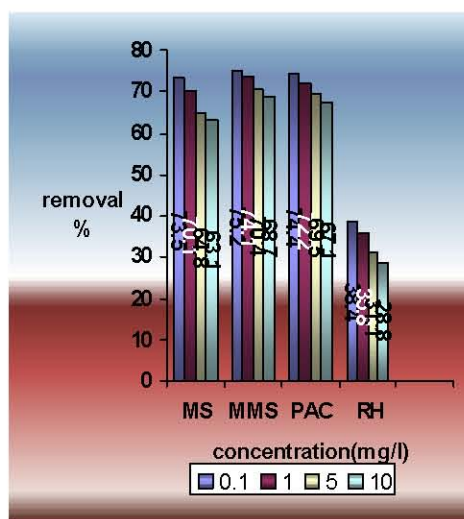


Fig. 6:

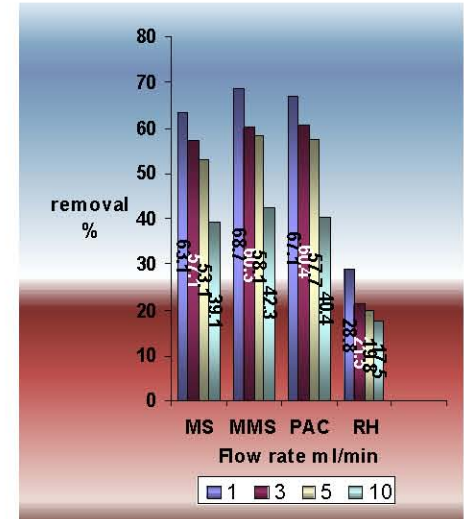


Fig. 9:

The order of mercury removal capacities for these chemical adsorbents was found to be MMS > MS > PAC > RH in both batch & column process. Adsorption decreases with rise in mercury concentration and pH, but increases with increase adsorbent dose and contact time. Equilibrium was attained in 5h and the maximum removal was at pH 6. Thus acidic medium favoured the removal. Leaching increases as the flow rate increases. Dilute HNO₃ was found profitably used to regenerate the spent sorbent.

CONCLUSION

MMS have comparable sorptive capacities to resins for mercury. They are easy to be cut, milled or ground. They can be used as cartridges for filtering processes. They are highly porous materials and are expected to be as ion exchangers, sorbents and filters etc.

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