TREATMENT OF POLLUTANTS IN WATER BY ADSORPTION USING SYNTHETIZED ACTIVATED CARBON-BIOPOLYMER COMPOSITES

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Abstract:

1. INTRODUCTION:

Water is a limited natural resource and fundamental for life and health. Water accumulates different type of compounds during its use becoming wastewater and unsuitable for reused. Water pollution with toxic compounds is one of major concerns for human health as well as for environmental quality. Toxic substances can be due to industrial pollution, urban pollution or agricultural pollution.

The pollutants frequently found are organics substances (dyes, solvents, hydrocarbons…), heavy metals (chromium, mercury, lead….) and/or chemical products (pharmaceutical products, personal care products…..).

Among industrial wastewater, dye wastewater from textile, tannery and dyestuff industries is one of the most difficult to treat. This is because dyes usually have a synthetic origin and complex aromatic molecular structures which make them stable and more difficult to be biodegraded.

Discharging different kinds of wastewater and polluted waters such as domestic, industrial and agricultural wastewaters into environments, especially to surface water, produce effluents which are often contaminated with harmful/poisonous substances. There are various methods for the removal of these substances. These broadly fall into three categories: Physical, chemical and biological. Any of these treatment processes have their own advantages and disadvantages.

With regard to increasing effluent discharge standards to the environment, high consideration should be taken when selecting proper treatment processes. Considering economical aspect are important, too. In addition employing environmentally-friendly methods for treatment is emphasized much more these days. Application of some waste products that could help in this regard, in addition to reuse of these waste materials, can be an advantage. Adsorption on a low cost activated carbon prepared from an agricultural waste has been a prominent method of treating aqueous effluent for a variety of separation and purification purposes.

Some rare works report on the association, within a unique material, of alginate and activated carbon for applications in water treatment, because the coupling of both materials may allow the elimination of a wide spectrum of pollutants.

The main objectives of this research work are: (i) preparation of H_2PO_4-activated carbon from apricot stone, calcium alginate beadsfrom sodium alginate solution, and calcium alginate/activated carbon composite beads, (ii) textural and chemical characterizationof the prepared adsorbents using N_2adsorption at $-196^\circ C$, SEM,FTIR and pH_{PZC} (iii) adsorption of methylene blueand ethyl violet from all solutions, which are previously prepared by the solid adsorbents, taking into account the kinetic and thermodynamic parameters, (iv) comparative studies between the two adsorbates toward alginate/activated carbon composites beads.

2. EXPERIMENTAL:

2.1. Materials and methods

Analytical grade reagents are used in all experiments. Basicdye, MB and IV (99%) is purchased from Merck Company, the chemicalstructure and properties of dyes are listed in Table 1.Activated carbon was prepared by a conventional method i.e.carbonization and chemical activation with phosphoric acid.Apricot stones, obtained from Setif region (Algeria), are air-dried, crushed and screened to obtain twofractions with geometrical mean sizes of 63 and 2.5 mm. 100 gof the selected fraction are impregnated with concentratedH_3PO_4(85%), dried in air and activated in a muffle furnace at250◦C (4 h). The carbonized material is washed with distilledwater to remove the free acid until the pH reaches 6.8 anddried at 105◦C. The clean biomass is mechanically ground andsifted to get powders with different particle sizes: <63nm.

Alginate/activated carbon composite beads (ACB) wereprepared by ionic gelation method[].

2.2. Batch mode adsorption studies

The effects of the experimental parameters such as the initial MB, IV concentration (50, 200, 500 mg L^{-1}), pH (3–10) and temperature (288–318 K) on the adsorptive removal of MB and IV ionswere studied in batch mode for a variable specific period ofcontact time (0–48h). The MB and IV content inthe supernatant was analyzed with a SHUMATZU UV–visiblespectrophotometer (λ_{max}= 664(MB), 494(IV) nm). The amountof MB and IV molecules adsorbed by ACB,q_t (mg g−1) wascalculated from the following equation:

where $C_0$is the initial MB and IV concentration, $C_t$is the MB and IV concentrations (mg L^{-1}) at any time, V is the volume of solution (L) andm is the mass of ACB (g).

3. RESULTS AND DISCUSSION:

3.1. Effect of pH

The degree of adsorption of ionic dyes onto the adsorbent sur-face is primarily influenced by the surface charge on the adsorbent,which is affected by the pH of the solution. It is seen from Fig. 3Bthat the maximum removal % of methylene blue takes place atpH > 6. The decrease in methylene blue removal at lower pH valuesmay be related to the protons competition with methylene blue forthe available adsorption sites.

3.2. Effect of initial concentration of MB:

The effect of initial MB concentration on % removal of MB and the actual amount of adsorbed MB was examined in the concentration of 25–500 mg/L and the obtained results are depicted in Fig.5. As shown, 100% from 91.87% removal percents for A-OB, were obtained for 20mg/L and 500mg/L of MB solution of initial concentration, respectively. The actual amount of MB adsorbed per unit mass of the A-OB increased with an increase in MB concentration as indicated by the data obtained. These phenomena can be ascribed to a significant decrease in the mass gradient between the adsorbent and the solution with increasing initial MB concentration [5]. It was also observed that as the initial MB concentration increased, the equilibrium MB removal reduced, and this may be due to MB adsorbent ratio [9].

3.3. Adsorption isotherm

It describes the relationship between the amount adsorbed bythe adsorbent and the adsorbate concentration remaining in thesolution. The adsorptions isotherms of methylene blue are studiedon the samples prepared (C, AB and ACB) at 20 and 40◦C and arepresented in Fig. 3C. It can be observed that, at the same tempera-ture the highest value for the adsorbed amounts was obtained forC followed by ACB, while the lowest value was those for AB. Thelinear form of Langmuir equation is given as:

The adsorption isotherm constants at three temperatures arelisted inTable 3. From Table 3, it was also observed that the valuesof 1/nwere all less than 1.0 for all temperatures, indicating that theBPAandTCPadsorptiononto theCTS/-Fe2O3/FACswas favourable[38]. Moreover, comparison of Langmuir and Freundlich isothermmodels for BPA and TCP adsorption onto CTS/-Fe2O3/FACs usingnon-linear regression were also illustrated in Figure SI (Supporting Information). By fitting the experimental data with LangmuirandFreundlich isothermequations, itwas also found that Langmuirisothermmodel fitted theequilibriumdata significantlybetter thanthe Freundlich model, indicating monolayer molecular adsorptionfor BPA and TCP.

4. CONCLUSIONS:

The present study confirmed that the prepared hydrolyzed oak sawdust calcium alginate composite has an effective adsorbent for removal of methylene blue dye from aqueous solution. Removal of methylene blue dye is pH dependent and the maximum removal was attained at pH 12.Also adsorption equilibrium data follows; Freundlich isotherm models.The ABC exhibits a remarkably high capability of RB2removal with the maximum capacity of 157.2 mg/g at 25 8C . ABC showed excellent regeneration capability, andmay be concluded that ABC may be used as a non-toxic, efficientmaterial and alternative to more costly adsorbents for theremoval of acidic dyes.