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Adsorption Studies on Activated Charcoal Prepared from Agricultural Wastes

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Activated charcoals have been prepared from the agricultural wastes of *Cajans cajan* and *Cicer arietinum* using chemical activating agents such as $ZnCl_2$ and orthophosphoric acid. Adsorption studies on the carbon samples TCzn, TCph and HCzn obtained from *Cajanus cajan* and *Cicer arietinum* have shown that all the materials have a good uptake capacity for acetic acid and oxalic acid. Langmuir adsorption isotherm is valid for all the carbon samples. Preliminary studies of adsorption of *p*-chlorophenol on all carbon samples have also given encouraging results.

TCzn = Charcoal from *Cajanus cajan* activated with 10% $ZnCl_2$
TCph = Charcoal from *Cicer arietinum* activated with 20% phos phoric acid
HCzn = Charcoal from *Cicer arietinum* activated with 10% $ZnCl_2$

Key Words: Charcoal, ***Adsorption, Cajanus cajan, Cicer arietinum.***

INTRODUCTION

In Maharashtra the crops Bengal gram, pulses, grapes, maize, cotton, wheat and bajra are harvested. Agricultural wastes from these crops are available in ample amount . These wastes can be exploited for getting useful adsorbents materials by carbonization. Effectiveness of carbonization is enhanced when the sources are impregnated with metallic salts like $CaCl_2$ or $ZnCl_2$. In the last two decades, a growing interest has been focused the use of H_3PO_4 as an activating agent in the production of activated carbon from both mineral and botanical sources[1–11]. The present study reveals the recovery of valuable adsorbents from readily and cheaply available agricultural wastes from *Cajanus cajan and Cicer arietinum.*

Activated carbons with a wide variety of pore size distribution are obtained by modifying the preparation conditions of either physical or chemical activation process. In both the methods there is a reaction of the precursor with the activating agent to develop the porosity[1, 12]. In a chemical activation process, the lignocellulosic precursor is mixed with a chemical in restricting the formation of tar after carbonization and washing, the final activated carbon is produced[1, 13].

The chemical incorporated in the interior of the precursor reacts with the products resulting from the thermal decomposition of the precursor, reducing the evolution of volatile matter and inhibiting the shrinkage of the particle.

The presence of incorporated phosphoric acid brings about a shift in the decomposition temperature (300°C) that prevents the burnout of char raises its yield. It is thus demonstrated that the temperature (800°C) is suitable for the production of activated carbon. In the present work activated carbon has been prepared by using 10% $ZnCl_2$ and 20% H_3PO_4 as activating agents.

Before studying the removal of metal ions, phenols, which are industrial wastes, it was thought appropriate to study the adsorption kinetics for acids such as oxalic acid and acetic acid. This paper presents the results of adsorption of oxalic acid and acetic acid on TCzn, TCph and HCzn samples.

EXPERIMENTAL

Tc and Hc were prepared by carbonizing the weighed stalks of *Cajan cajan and Cicer arietinum.* Different materials required different time for complete carbonization procedure. Completion of procedure was detected by the back suck of water from side arm tube, which was placed in a beaker. Carbonization of *Cajan cajan* gave 32.59% of charcoal (Tc) and of *Cicer arietinum* gave 28.59% of charcoal (Hc). Unactivated *Cajanus cajan* charcoal (Tc) and *Cicer arietinum* charcoal (Hc) was dipped in 10% $ZnCl_2$ solution and kept for 24 h, filtered through Whatmann paper no. 41 and washed with 2 N HCl to remove zinc and washed with water till washings show pH = 7. The charcoal (TCzn, HCzn) thus prepared was passed through sieves to get particles of uniform size (53 micron). Small pieces of *cajan cajan* stalks were weighed and dipped in 20% phosphoric acid for 24 h. Stalks are removed and dried in an oven at 100°C, kept in a muffle furnace for 2 h at 850°C. The charcoal (TCph) was washed with distilled water to make pH = 6–6.5. TCph was passed through sieves to get particles of uniform size (63 micron). Samples used for adsorption study of acetic acid were TCzn and TCph. Samples used for adsorption study of oxalic acid were TCzn and HCzn.

Adsorption study was carried out by reported literature procedure.[14]

RESULTS AND DISCUSSION

The data obtained from adsorption study of acetic acid and oxalic acid on TCzn, TCph, HCzn and animal charcoal (AC) have been fitted into Langmuir adsorption isotherm. The plots of $C_e/(x/m)$ against C_e (Figs. 1, 2 and 3) for all the above mentioned samples were found to be linear, indicating applicability of the Langmuir equation. $C/(x/m) = 1/ab + (1/b)c$.

A comparison of adsorption capacity of the different charcoal samples (TCzn and TCph) is found to be comparable with the adsorption capacity of animal charcoal. The data for adsorption of acetic acid on TCzn and TCph show that concentration 0.4 to 0.5 moles/L is the best suited concentration at RT (Table-1).

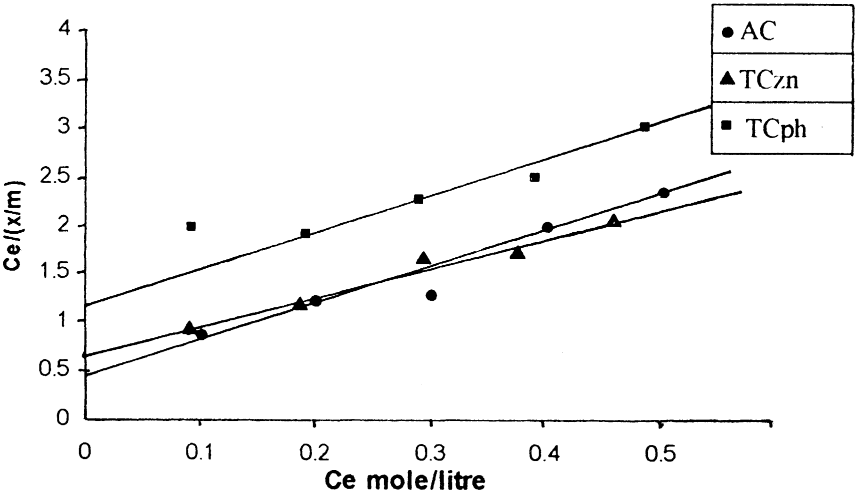

Fig. 1. Adsorption isotherms for oxalic acid on AC, TCzn, TCph

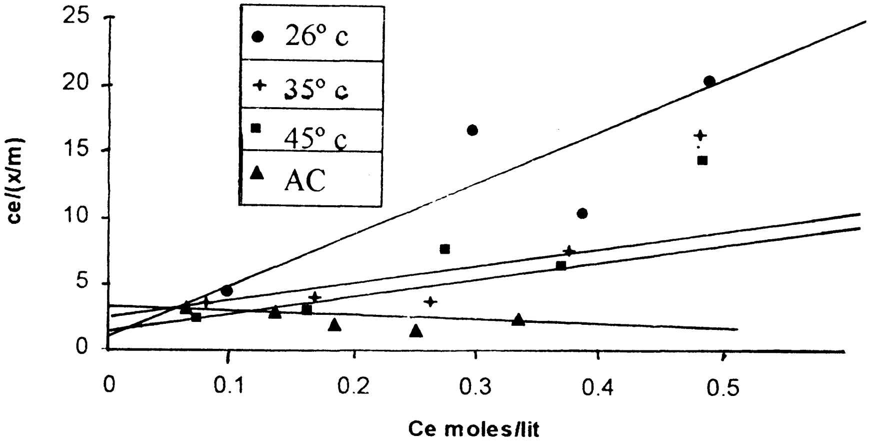

Fig. 2. Adsorption isotherms for oxalic acid on HCzn at different temperatures

TABLE-1
ADSORPTION CAPACITIES OF AC, TCzn & TCph FOR ACETIC ACID

C_0 (mol/L)	x/m mol g L^{-1} for AC	x/m mol g L^{-1} for TCzn	x/m mol g L^{-1} for TCph
0.1	0.108	0.102	0.050
0.2	0.160	0.163	0.101
0.3	0.230	0.197	0.132
0.4	0.200	0.229	0.163
0.5	0.210	0.224	0.166

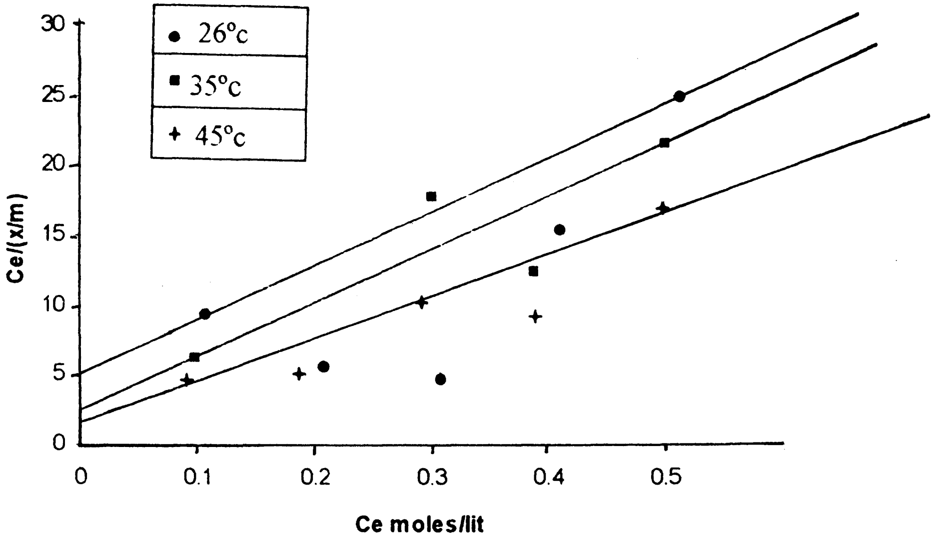

Fig. 3 Adsorption isotherms of oxalic acid by TCzn at different temperatures

A plot of initial concentration of oxalic acid (Co) against adsorption capacity (x/m) of TCzn at 26°C indicates that 0.2 mol/L is the best suited concentration for adsorption on TCzn (Fig. 4).

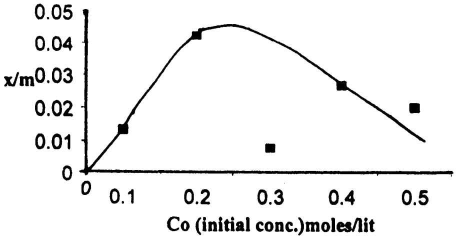

Fig. 4. A plot of Co against adsorption capacity (x/m) of TCzn

A plot of initial concentration of oxalic acid (Co) against adsorption capacity (x/m) of HCzn at 35°C indicates that 0.3 mol/L is the best suited concentration for adsorption on HCzn (Fig. 5).

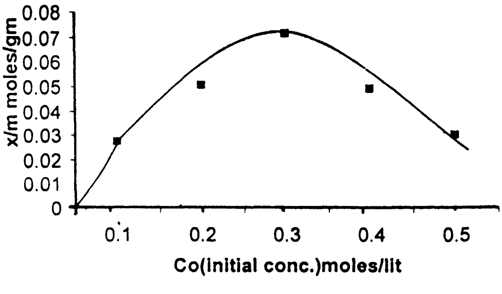

Fig. 5. A plot of Co against adsorption capacity (x/m) of HCzn at 35°C

The x/m values of TCzn and HCzn indicate that of the two samples, HCzn shows better adsorption of oxalic acid compared to TCzn at 35°C. (Table-2)

TABLE-2
ADSORPTION CAPACITIES OF TCzn AND HCzn FOR OXALIC ACID AT 35°C

C_0 (moles/L)	x/m mole g L^{-1} for TCzn	x/m mole g L^{-1} for HCzn
0.1	0.0192	0.0272
0.2	—	0.0504
0.3	0.0176	0.0716
0.4	0.0368	0.0488
0.5	0.0240	0.0300

The Langmuir parameter 'b' has been obtained from slope[15] and is shown in Table-3. The values for 'b' increase with temperature, suggesting that the adsorption is endothermic and entropy dominated.

TABLE-3
PARAMETER (b) OF LANGMUIR EQUATION FOR THE ADSORPTION OF OXALIC ACID ON TCzn AND HCzn

Temperature (K)	b (mole L^{-1} g^{-1}) for TCzn	b (mole L^{-1} g^{-1}) for HCzn
293	0.02400	0.0320
308	0.02491	0.0714
318	0.03200	0.0800

Preliminary studies of adsorption of nitrophenols, *p*-chlorophenol have also given encouraging results. Plot of concentration of *p*-chlorophenol at $\lambda_{max} = 225$ nm against absorbance is shown in Fig. 6.

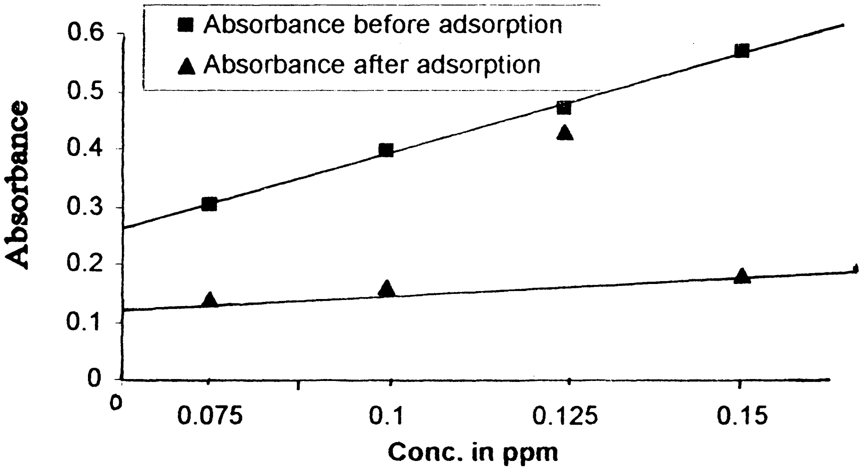

Fig. 6 Adsorption of *p*-chlorophenol on TCph

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