Physically activated carbons from hypercrosslinked polymers for wastewater remediation

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Introduction

Low value Coal tar products (CTPs), obtained from the distillation of coal tar, were used as precursors for the synthesis of hypercrosslinked polymers (HCPs). HCPs are carbonized and activated in order to obtain useful porous carbons for the treatment of underground coal gasification (UCG) wastewaters. The porous texture of the activated carbons (ACs) could be turned to allow the adaptation of the pore size to the size of the contaminant of interest, improving by this way, the efficiency of the wastewater treatment. As we have used precursors of different natures, polymers with different porous textures were obtained, therefore, we can make a more in-depth analysis of the efficiency of the obtained carbons to remove pollutants.

Experimental

The CTPs were processed into HCPs by means of the Friedel-Crafts chemistry, where formaldehyde dimethyl acetate acted as crosslinker and $FeCl_3$ as catalyst. The next step is the carbonization of the HCPs at 850 °C, for 1 hour under inert atmosphere. The obtained chars were physically activated at 800 °C under CO_2 flow for 30 hours in order to improve the porosity of the materials. Finally, the chars were washed with HCl and distilled water to eliminate decomposition products.

The resulting activated carbons were characterized by N_2 adsorption-desorption at -196 °C and CO_2 at 0 °C. The adsorption capacity of the ACs was tested by shaking them in a phenol solution (2 g/L) for 24 hours at 25 °C. Finally, the resultant concentration of the pollutant was measured by UV-vis spectroscopy.

Results and discussion

Table 1 shows the burn-off (BO) for each of the precursors, obtaining very different values, ranging between 16 and 61 wt. %, so it can be deduced that the BO degree is highly dependent on the precursor used. This fact can also explain the variety of BET specific surface areas (S_{BET}) we have obtained, ranging between 833 and 1657 m^2/g.

Table 1. Burn off, porous textural parameters, and amount of adsorbed phenol

CTP precursor	BO (wt. %)	S_{BET} (m^2/g)	V_{CO_2} (cm^3/g)	Adsorbed phenol (mg/g)
Distilled coal tar pitch (DCTP)	32	944	0.36	216
Wash oil (WO)	36	1208	0.44	294
Chrysene oil (CO)	22	833	0.32	167
Phenolic oil (PO)	27	956	0.37	185
Creosote B (CreoB)	27	1039	0.41	216
Naphthalene oil (NO)	47	1312	0.46	260
Depleted naphthalene oil (DNO)	43	1236	0.43	238
Distilled coal tar (DCT)	16	824	0.33	195
Anthracene oil (AO)	61	1657	0.52	316

Physisorption analysis is the best technique to determine the porous structure of the activated carbons, obtaining type I isotherms according to the IUPAC classification (Figure 1a). This type of isotherm is characteristic of microporous solids with a small external surface, however, in some samples a slight widening of the isotherm knee can be observed, which indicates that the sample presents wider micropores.

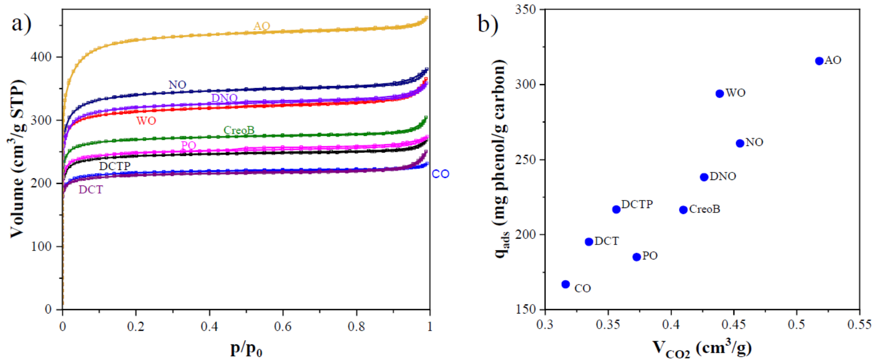

Figura 1. a) N_2 adsorption/desorption isotherms and b) Relationship between the amount of phenol adsorbed (qads) and the micropore volume (V_{CO_2})

These carbons were applied for the treatment of water contaminated with phenol, as adsorbent, showing a strong dependence between the micropore volume obtained from the CO_2 adsorption isotherm (V_{CO_2}) and the adsorbed amount of this pollutant (Figure 1b.). As seen in Table 1 and Figure 1b, the higher the number of narrow micropores, the more phenol will be adsorbed by the ACs. This can be explained because the phenol has a size in the micropore range, so the more micropores our AC has, the more phenol will be adsorbed [1].

Conclusiones

Carbons with different SBET have been obtained from HCPs when they are physically activated, becoming promising adsorbents for wastewater treatment, since they are capable of adsorbing a considerable amount of pollutant.

We obtain an activated carbon with the best textural characteristics when anthracene oil (AO) is the precursor, as it is able to adsorb the highest amount of phenol compared to when other precursors are used.

In addition, it is also important to test these activated carbons with other wastewater pollutants, so more studies are currently ongoing with other organic compounds (e.g. toluene) and heavy metals (e.g. lead and chromium).

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Referencias

[1] E. Lorenc-Grabowska, Effect of micropore size distribution on phenol adsorption on steam activated carbons, Adsorption, 2016; 599–607.