458b Activated Carbon Fibers Versus Gac

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Phenolic compounds have been a major environmental concern because they exist widely in industrial effluents such as those from oil refineries and coal tar, plastics, leather, paint, pharmaceutical, and steel industries. Granular activated carbon (GAC) has been found to be effective in removing these compounds. However, phenolic compounds undergo oligomerization on the activated carbon surface when molecular oxygen is present in the test environment and appreciable increase in adsorptive capacity had been noticed at the cost of lower GAC regeneration efficiency after being exhausted by the contaminant. Many studies have been conducted to investigate the surface properties of GAC on the oligomerization reaction, yet none provided a conclusive result. Compared with GAC, activated carbon fibers (ACFs) have low ash and surface oxide content which results in minimal effects of inorganic impurities on pore development during the activation process. The controlled and uniform pore structure makes ACFs ideal for targeting the impact of pore size on the adsorption phenomena.

Liquid phase adsorption of phenolic compounds on GAC and ACFs was conducted in this study to investigate the impact of pore size distribution (PSD) of adsorbents and adsorbate properties on oligomerization. The adsorbents were GAC F400 and four types of ACFs (ACC-10, ACC-15, ACC-20 and ACC-25). F400 has a wide pore size range, 4-800 Å, and the micropores are branched from the macropores. On the other hand, ACFs have limited PSD and their critical pore diameter depends on the activation process. ACC-10, ACC-15, ACC-20 and ACC-25 have critical pore diameters 8.0, 12.8, 17.4 and 19.7 Å, respectively. The micropores of ACFs are directly on the adsorbent surface. The adsorbates studied were phenol, 2-methylphenol, 2-ethylphenol, 2-chlorophenol, and 2-nitrophenol. These adsorbates are typical phenolic pollutants and have different molecular dimensions and critical oxidation potential (COP). Single solute and multicomponent adsorption were conducted under anoxic and oxic conditions using the bottle point method. The dissolved oxygen (DO) for the anoxic isotherms was maintained under 1 mg/L and for the oxic isotherms, DO was not lower than 15 mg/L. Concentration determinations were made by gas chromatography (GC) separation equipped with Agilent DB-5 column and flame ionization detector (FID).

Single solute adsorption was found to be well described by Myers equation. Figure 1 indicates that the oxic adsorptive capacity is higher than the anoxic ones in most cases. 2-nitrophenol did not show any difference between the oxic and anoxic isotherms for all adsorbents studied which is related to its high COP as compared to the other adsorbates. The oligomerization extent for all compounds studied except for 2-nitrophenol were ACC-10 < ACC-15 < ACC-20 < ACC-25 and this sequence is in accordance with the increase of the critical pore diameter of the ACFs. The fact that ACC-25 showed similar oligomerization extent with F400 indicates that PSD played a more crucial role in oligomerization than the adsorbent surface functional groups since F400 has different surface properties as compared to the ACFs. As for the adsorbates, the oligomerization degree is in accordance with COP, that is 2-methylphenol > 2-ethylphenol > phenol > 2-chlorophenol.

Binary adsorption (phenol / 2-methylphenol, 2-methylphenol / 2-ethylphenol, 2-methylphenol / 2-chlorophenol and 2-methylphenol / 2-nitrophenol) was conducted on F400, ACC-10 and ACC-15. No difference between anoxic and oxic isotherms was detected on ACC-10 (Figure 2). The binary anoxic and oxic adsorption on ACC-10 was well predicted by the Ideal Adsorbed Solution Theory (IAST), using the Myers equation for correlating the single-solute anoxic isotherms. For the binary isotherms on ACC-15 and F400, higher adsorptive capacity was detected for oxic isotherms than anoxic ones and

IAST well predicted only the anoxic isotherms while under predicted the oxic ones indicating occurrence of oligomerization (Figure 2).

Anoxic and oxic ternary adsorption of phenol/2-methylphenol/2-ethylphenol and 2-methylphenol/2-chlorophenol/2-nitrophenol was conduced on F400 and ACC-15. The difference between anoxic and oxic isotherms on ACC-15 is negligible and the IAST predictions for both anoxic and oxic conditions were reasonably well. But for F400, IAST predicted well only the anoxic isotherms and under predicted the oxic isotherms. In multicomponent adsorption, the available site for the compound to get oligomerized is less as compared to single solute adsorption and the limited PSD of ACFs was shown to be effective in hampering oligomerization.

In order to further elucidate the oligomerization behavior, adsorbents loaded with the phenolic compounds were extracted by methanol and dichloromethane using soxhlet apparatus. For the oxic single solute isotherms, higher extraction efficiency was achieved for the ones that showed lower oligomerization. Oligomerization bonds were detected by FT-IR for the carbon that showed oligomerization and these oligomerization bonds were still detectable after extraction. Traces of oligomers in the extracts were also detected by GC/MS.

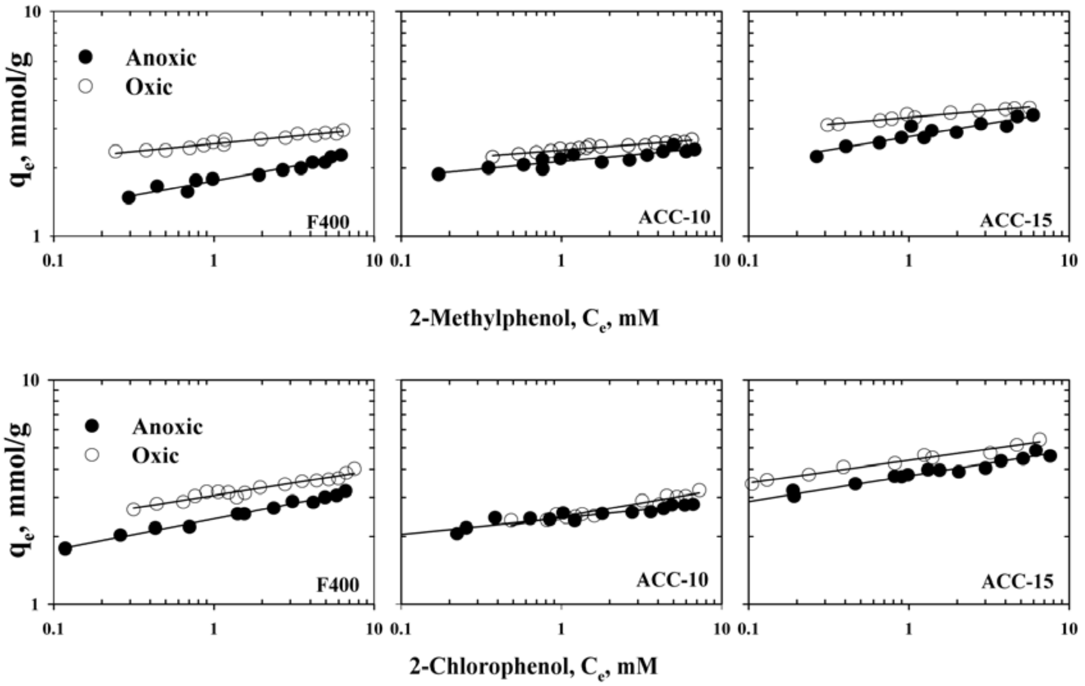

Figure 1 Single solute adsorption of 2-methylphenol and 2-chlorophenol

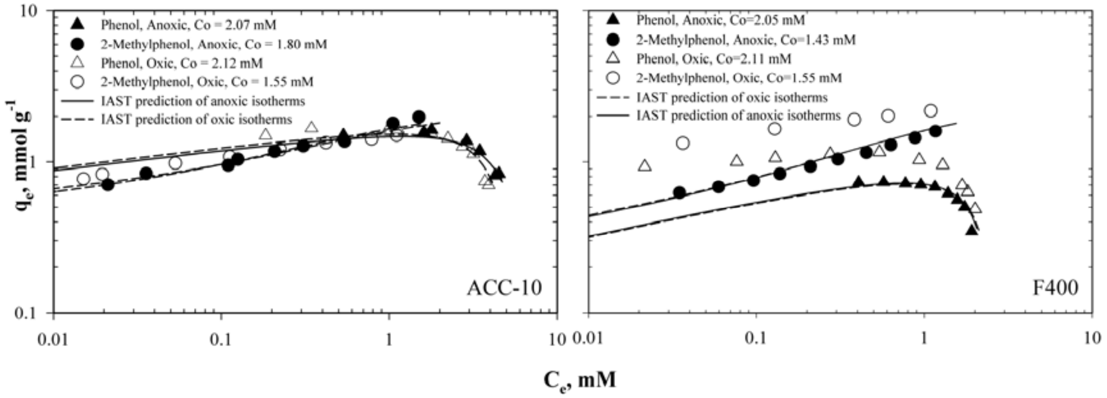

Figure 2 Binary adsorption of phenol and 2-methylphenol on ACC-10 and F400