

## Characterisation of Surface Ionisation and Adsorption of Phenol and 4-Nitrophenol on Non-porous Carbon Blacks

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**ABSTRACT:** The adsorption of phenol and 4-nitrophenol from aqueous solutions by carbon blacks was studied. Particular attention was paid to the characterisation of the surface chemistry and ionisation of the carbon blacks by use of a simple carbon surface ionisation model, as well as the use of a normalised form of the Freundlich equation for the analysis of the adsorption isotherms. The results indicated that the solutes interact directly with the graphene layers and that the adsorption is sensitive to the  $\pi$ -electron density. Phenol has a weaker interaction and is more sensitive to the system conditions. In particular, it is more sensitive to oligomerisation under certain conditions. Comparison of the results with those previously reported for activated carbons with similar points of zero charge prepared from cork confirms the existence of a significant micropore-narrowing effect in the adsorption of organic solutes by activated carbons and which can lead to up to a doubling of the value of the Freundlich exponent,  $n_p$ .

### INTRODUCTION

A large amount of work has been published on the adsorption of phenolic and other organic compounds by activated carbons (Dabrowski *et al.* 2005; Mattson and Mark 1971; Moreno-Castilla 2004; Radovic *et al.* 2000), including recent work published in this journal (Ania *et al.* 2007; Asadullah *et al.* 2006; Gad and Daifullah 2007; Lambrecht *et al.* 2007; Termoul *et al.* 2006; Valente Nabais *et al.* 2007; Zhang *et al.* 2006; Zou and Han 2001). However, as a result of the complexity of the solid/solute/solvent system, there still remains much uncertainty over many aspects of the adsorption mechanism, such as the precise role of surface groups, the effect of solute solubility and ionisation, and the influence of pore size, amongst others. In principle, the complexity of the system could be decreased by carrying out complementary studies using non-porous carbon materials such as carbon blacks. For over 40 years this has been a standard procedure when considering gas-phase adsorption, where comparative methods such as the  $t$ - and  $\alpha_s$ -methods are amongst the most widely used procedures for analysing adsorption isotherms (Lippens and de Boer 1965; Setoyama *et al.* 1998; Sing 1969). It is somewhat surprising therefore to find that comparatively little work on adsorption from dilute aqueous solutions by carbon blacks has been published so far (Asakawa and Ogino 1994; Fernández *et al.* 2003; Gómez-Serrano *et al.* 1994; González-Martin *et al.* 1991, 1994; Kamegawa *et al.* 2005; Király *et al.* 1996; Mahajan *et al.* 1980; Stoeckli *et al.* 2001).

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