

Separation Techniques 2018 - Novel surfactant modified porous graphitic carbon: an effective and sustainable adsorbent for organic dye removal

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An environmentally friendly and economically effective surfactant modified porous graphitic carbon (S-PGC) was successfully fabricated to be used as a high efficiency sorbent for removing organic dyes from simulated water samples. The novel adsorbents prepared by pre-treating the porous graphitic carbon (PGC) prepared from alginate biomass using conventional anionic surfactants such as sodium dodecyl sulfate (SDS) and sodium dodecyl benzene sulfonate (SDBS) exhibited excellent adsorption performance for removal of cationic organic dyes such as methylene blue (MB), methyl violet (MV) and methyl yellow (MO). As compared to PGC of meso and microporous character, the developed S-PGC adsorbent achieved excellent adsorption capacities (>90%) and faster adsorption kinetics for the elimination of organic dyes even at very high dye concentrations of 1000 mg/L. Anchoring of the surfactant on the surface of the graphitic carbon is believed to improve its affinity towards the dyes owing to the narrowing of the pore opening and existence of abundant hydroxyl, ether and amine groups. Based on the high efficiency, feasibility and recyclability, surfactant modified graphitic carbon prepared from alginate biomass exhibits a great potential for water purification. PGC and surface charge PGC is a conductor and will thus obtain the same redox potential as the surrounding solution. For instance, when PGC is exposed to a mobile phase with a more positive redox potential than the point of zero charge (PZC) of PGC (i.e. $E_{app} > PZC$), a positively net charge will result on the surface, see a. In a similar way, a negatively charged surface will result when PGC is in contact with a solution of a more negative redox potential than The surface charge of PGC when the redox potential is (a) more positive ad (b) more negative than the point of zero charge (PZC) of PGC. The surface charge of PGC has

proven to be important for the characteristics of PGC.²⁶ In electrochemically modulated liquid chromatography²⁶ (EMLC), Porter and co-workers altered the applied electrochemical potential on the PGC stationary phase and thereby changed the retention for different analytes, e.g. arene sulfonates. The surface charge on PGC may, however, be changed by different approaches. In Paper I another approach was used, namely chemical oxidation of packed PGC columns using permanganate. By applying this chemical strategy for oxidation of PGC, the retention characteristics of the packing material were initially significantly altered as described in the following Section. Chemical oxidation of PGC When PGC is oxidized by a strong oxidizing agent, like permanganate, two closely related phenomena occur. First, the surface charge is altered.

Secondly, surface groups¹ present on PGC can be oxidized. If the surface charge is changed, alteration of the retention on PGC has been reported.²⁶ Likewise, the second phenomenon, i.e. the oxidation of surface groups may give rise to a change in the retention. In Paper I, it is shown that the chromatographic behavior of oxidized PGC columns is significantly different from that of non-oxidized PGC columns. When the analytes (dopamine, DOPAC and heparin disaccharide) were injected on oxidized PGC columns, no clear peaks originating from the analytes were observed during the first day(s). Hence a dramatic change in the retention of all compounds was initially seen on the PGC columns oxidized with permanganate. Thereafter, when the oxidized columns were equilibrated several days by pumping mobile phase through them, the column regained its original properties and the analytes eluted from the columns with similar retention factors as for the non-oxidized

PGC columns. The behavior of oxidized PGC, as described above and reported in Paper I, demonstrates that the properties of the oxidized PGC columns are unstable and approach the chromatographic properties of non-oxidized PGC columns with time. One possible explanation for the observed alterations in the retention characteristics of oxidized PGC, could be that the conducting PGC material is in contact with a solution that slowly changes its redox potential with time. A decrease in redox potential (and hence a change in surface charge) of the oxidized PGC will result when mobile phase is passed through the column during the equilibration. In the beginning, i.e. immediately after the oxidation with permanganate, a quite positive redox-potential of PGC should result. However, as the permanganate concentration in the column is decreasing the redox potential of PGC would also decrease, since the redox potential of the mobile phase lacking permanganate is lower than the redox potential of a permanganate solution. The decreased concentration of permanganate in the column would quite rapidly alter the surface charge (and thereby the chromatographic properties) of PGC. Additionally, a more time consuming process is involved in the chemical oxidation and alteration of the chromatographic properties of PGC. This process can be described as follows: initially an oxidation of surface groups on the PGC by the permanganate occurs. This is followed by a slow replacement of the functional groups by components present in the mobile phase. This is possible since the redox potential of the mobile phase used during the equilibration (and separations) was found to be significantly lower (approximately + 0.5 V) than the redox potential of the potassium