Enhanced adsorption of perfluorooctanoic acid (PFOA) onto low oxygen content ordered mesoporous carbon (OMC): Adsorption behaviors and mechanisms

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Abstract

Ordered mesoporous carbon (OMC) can adsorption perfluorooctanoic acid (PFOA) fast from water. The mesopores play an important role in this rapid adsorption kinetics. The OMC-900 with a low oxygen content has a high PFOA adsorption capacity. The hydrophobic interaction and electrostatic interaction adsorption mechanisms were proposed and verified by the adsorption data. Various background salts showed a positive effect on PFOA adsorption due to the salting-out and divalent bridge effects.

Synthetic of OMCs

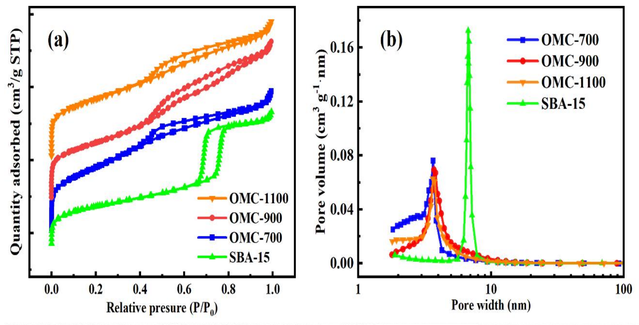
Preparation of SBA-15 template

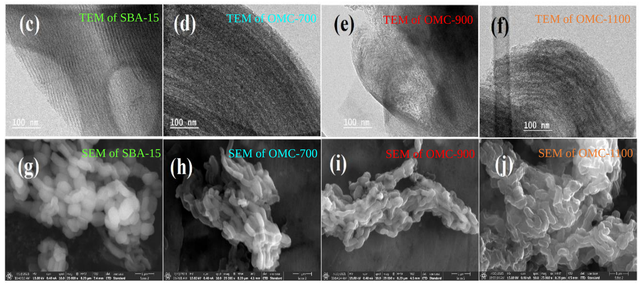
- Pluronic P123, HCl solution, and TEOS were added to distilled (DI) water and keep stirring.
- The mixture aging at 90° C for 24 h .
- The SBA-15 was obtained after calcinated at 550 ° C.

Preparation of OMCs

- Sucrose, concentrated H_2SO_4 and SBA-15 was added to the DI, heated in oven at 100° C for 6 h and 160° C for another 6 h.
- The resulting composite was carbonized at 700° C, 900° C, and 1100° C for 6 h under N_2 flow.
- Finally, the SBA-15 template was removed by HF.

Morphology of OMCs



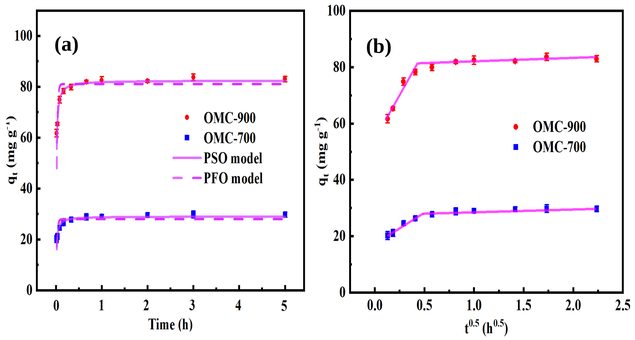


Elemental Composition of OMCs

Sample	C%	O%	S%	N%	H%	O/C
OMC-700	83.49	14.25	0.42	0.31	1.53	0.1707
OMC-900	88.50	9.71	0.26	0.32	1.21	0.1099
OMC-1100	90.63	8.03	0.27	0.30	0.81	0.0886

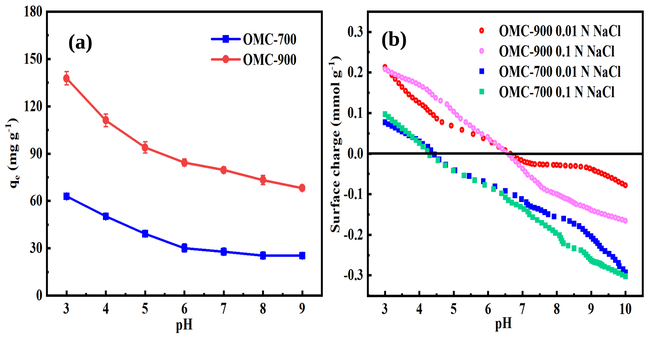
- Carbon is the main component of OMCs.
- Increase the calcinate temperature, increase the hydrophobicity.

Adsorption Kinetics



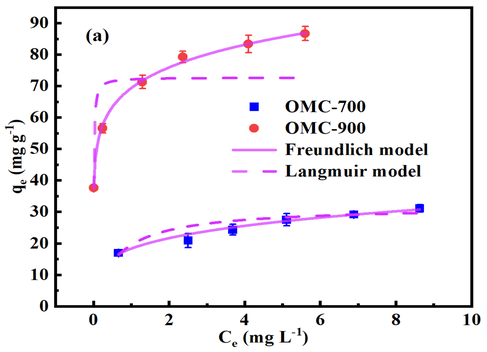
- The adsorption equilibrium was reached within 1 h.
- The Intra-Particle Diffusion model fitting shows a multi-linear relationship.
- The adsorption process is not only controlled by the intra-particle diffusion.

Effect of Solution pH



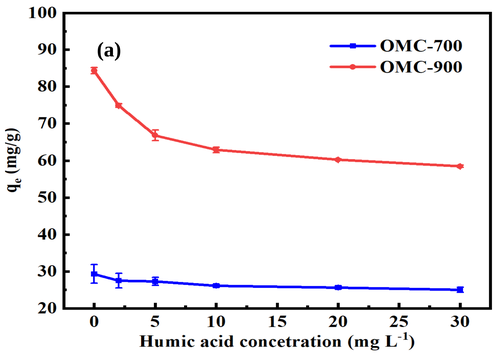
- The adsorbed amounts of PFOA decrease continuously from pH 3.0 to 9.0.
- The electrostatic attraction might occur during the adsorption.
- The more positively charged OMC-900 explains its higher adsorption capacity.
- The hydrophobic interaction could overcome the electrostatic repulsion.

Adsorption Isotherms



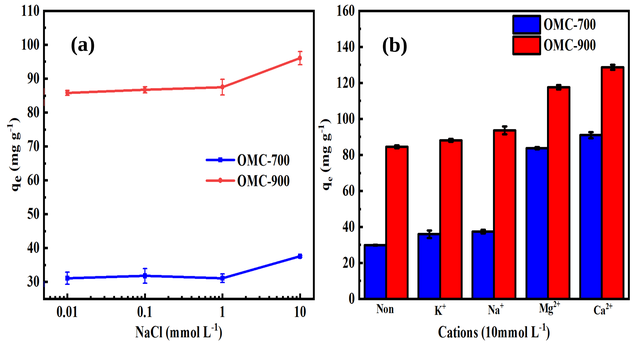
- The oxygen-containing functional groups increased the hydrophilicity but decreased its PFOA adsorption capacity.
- Multi-layer micelles and hemi-micelles may form on the OMCs surface via hydrophobic interaction.

Effect of Humic Acid (HA)



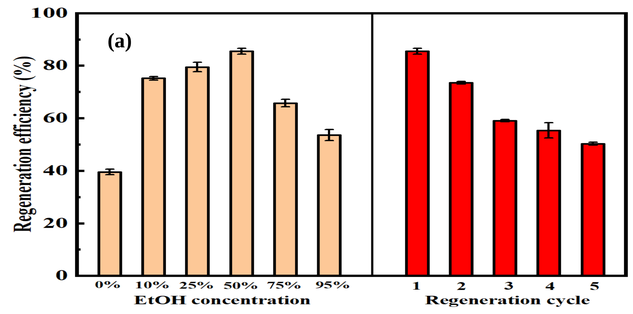
- OMC-900 can adsorb more HA, and the reduction of PFOA adsorption onto OMC-900 is more significant than that of OMC-700.

Effect of Ionic Strength and Cations



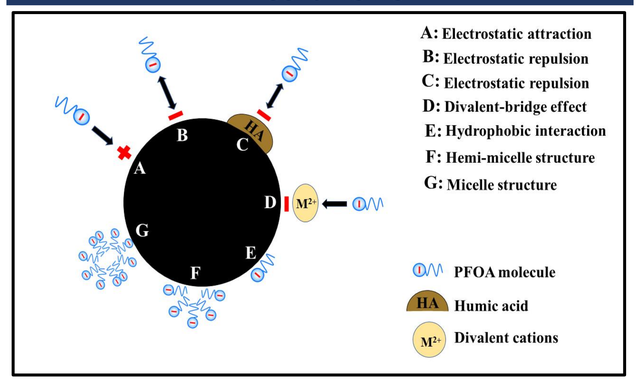
- The presence of the salts improve the adsorption performance.
- The divalent cations like Mg^{2+} and Ca^{2+} could act as the bridges, connecting the PFOA with OMCs, improve their adsorption performance.

Regeneration Study



- 50% EtOH solution shows a best regeneration efficiency.

Mechanisms



Conclusions

- Oxygen content plays an important role in PFOA adsorption.
- The micelle and hemi-micelle structure may be formed during the adsorption.
- The cations in the solution improved the adsorption.
- Hydrophobic interaction and electrostatic interaction are the main adsorption mechanisms.

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