Efficient Removal of 17α-Ethinylestradiol from Water Using Silica-Based Adsorbents: Impact of Organic Functionalities and Water Matrices

Tiago Morais[1,2], Diogo Pereira[3], Geraldine Sequera[1], Ana C. Moreira[1], Marina Ilkaeva[1,4], Luís Mafra[1], Mariana Sardo[1], Vânia Calisto[1], Mirtha A. O. Lourenço[1]

[1] *CICECO - Instituto de Materiais de Aveiro, Department of Chemistry, University of Aveiro,Campus Universitário de Santiago, 3810-193, Aveiro, Portugal*

[2] *Department of Chemistry, University of Iceland, Science Institute, Dunhaga 3, 107 Reykjavik, Iceland*

[3] *CESAM, Department of Chemistry, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal*

[4] *Department of Chemical and Environmental Engineering, University of Oviedo, Av. Julián Clavería 8, 33006 Oviedo, Spain*

tiagomorais@ua.pt

Three silica-based porous adsorbents – MCM-41 (pure silica), vinyl-MCM-41 (hybrid silica), and Ph-PMO (periodic mesoporous phenylene-silica) – were tested to evaluate the effect of organic functionalities on removing the hormone disruptor 17α-ethinylestradiol (EE2) from water. Adsorbent dosages were tested in ultrapure water spiked with 200 μg L^{-1} of EE2, and the results revealed that concentrations higher than 500 mg L^{-1} of adsorbent did not significantly enhance the EE2 removal efficiency. Both materials containing organic functionalities (using a dose of 500 mg L^{-1}) were tested in ultrapure water, phosphate buffer at pH 5, 7, and 9, and wastewater effluent to evaluate the pH impact and effect of different water matrices on their adsorption performance. An increase in pH significantly improved the EE2 adsorption capacity of Ph-PMO, reaching 94 ± 2 % at pH 9, while it decreased the adsorption efficiency of vinyl-MCM-41 to 14 ± 7 % at the same pH. Following a comprehensive characterization of the materials, including assessments of chemical stability across varying pH conditions, point of zero charge, hydrophobicity, and textural properties such as specific surface area, pore volume, and pore diameter, the findings suggests that the homogenous distribution of organic functionalities in Ph-PMO enhances surface interactions, such as π-π stacking and hydrophobic interactions, with the EE2 hormone. Ph-PMO demonstrated superior performance in wastewater effluents, and kinetic studies showed rapid EE2 adsorption across all matrices, reaching equilibrium within 5 minutes. This study highlights the suitability of Ph-PMO for water remediation applications.

Figures

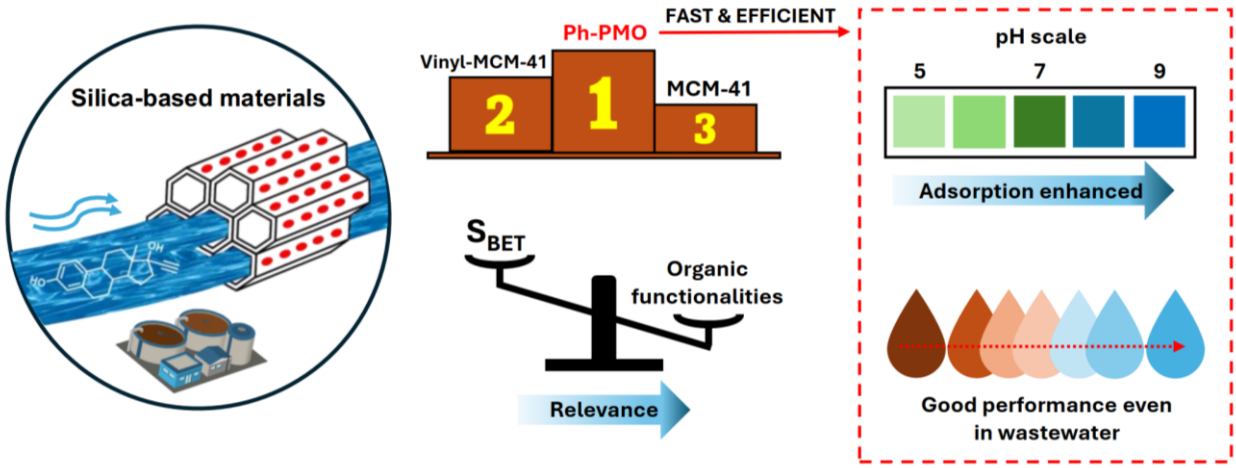

Figure 1: Graphical abstract.