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Highly adsorptive removal of palladium and platinum ions from wastewater using novel ethylenediamine-glutaraldehyde-grafted metal organic framework

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Abstract

Herein, a metal–organic framework (MIL-101(Cr)) was synthesized and functionalized with ethylenediamine-glutaraldehyde (ED-GA for removal of palladium (Pd2+) and platinum (Pt4+) from wastewater. The chemical structure, surface properties, morphology, and adsorption energy of the prepared materials, MIL-101(Cr) and MIL-101(Cr)/ED-GA were analyzed using several analytical techniques and density functional theory (DFT). The prepared MIL-101(Cr)/ED-GA was efficient in removing Pd2+ and Pt4+ from aqueous solution with the percentage removal reaching 95% for Pd2+ and 85% for Pt4+. Furthermore, the adsorption data demonstrated a good fit to the Langmuir isotherm model and gave the maximum adsorption capacity values of 416.17 mg g-1 for Pt4+ and and 322.6 mg g-1 for Pd2+ ions. Kinetics data obeyed a pseudo-second-order model and revealed the rapid adsorption of Pd2+ and Pt4+ ions by MIL-101(Cr)/ED-GA which reached equilibrium within 10 and 40 min, respectively. Lastly, DFT studies revealed that the adsorption of Pd2+ ions by the composite forms a more thermodynamically stable compound than adsorption of Pt4+, suggesting that the material easily interacts with Pd and high selectivity is thus expected. This was indeed confirmed by experimental selectivity test results. Owing to their high affinity for PGMs, N atoms depicted large adsorption energy values compared to other adsorption sites. The MIL-101(Cr)/ED-GA could act as an efficient and cost effective adsorbent for removal of platinum group metals from wastewater.