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Rapid removal of uranyl ions from aqueous medium using amide-phosphate functionalized Graphene oxide (NH-PO@RGO)

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Uranium is a naturally occurring hazardous radioactive element with mutagenic properties, which is found in various parts of the world with specific geological constituents. It exists in different chemical species but UO22+ is the most abundant species which was exist both in acidic and neutral pH, hence it can be transported from groundwater to soil to food chain and consequently pose health hazards. Further, due to different anthropogenic activities elevated uranium concentrations in groundwater were found in various locations of the world as to be higher than its permissible limits of 15 ppb and 30 ppb defined by WHO and USEPA. Among various removal methods adsorption is found to be the most attractive for removal of uranium due to its high efficiency, low operational cost and ease of operation. Wide range of materials is reported as adsorbents for uranium removal such as MOFs, amine modified silica etc. but bi-functionalized adsorbents for uranium removal were not studied therefore amide, phosphate bi-functionalized reduced graphene oxide has been explored for uranium removal. Due to high surface area and high availability of functional groups, e.g., carboxylic, phenolic group, and ethers on the surface, graphene oxide was considered the good candidate for functionalization. In our study, graphene is modified with adenosine 5/ monophosphate (AMP), to avail multiple interaction sites for uranyl ions including the phosphate oxygen and amine nitrogen which converted to amide nitrogen using a linker. The as-synthesized adsorbent is represented as NH-PO@RGO. Batch experiments for pH, dose, and kinetics were performed and concentration of uranium was quantified by ICP-OES. The adsorption followed a pseudo second order kinetic model and Langmuir adsorption isotherm, which revealed a high adsorption capacity (qmax) of greater than 3000 mg g-1 corresponding to 93% removal of uranyl ions in 240 s at an optimized dose at pH 6. Such high uranyl ion adsorption is due to the linking of uranyl ions with the phosphate oxygen and with the aromatic nitrogen of the purine residue of AMP. The sustainability of NH-PO@RGO as an adsorbent has been demonstrated by showing the regeneration and re-usability of the adsorbent for 5 cycles.