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Nanoporous 2D Materials for the Exceptional Selectivity of Dissolved Silicas for Waste Water Remediation and Reuse

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Dissolved silica is ubiquitous in impaired waters, resistant to existing anti-scalants, and difficult to remove from power plant feedwaters. Thermoelectric power generation is the largest user of freshwater in the US, at *~500 billion gallons/day which is almost half of all water withdrawn daily*. Replacement of that freshwater with purified oilfield produced waters, municipal or agricultural wastewaters, and subsurface brines is possible only if dissolved silica and calcite are prevented from forming mineral scales during the power generation process. Existing anti-scalant technology can already prevent calcite buildup. However, there is no low energy method for preventing silica scaling, thereby limiting the amount of impaired water recycling that can be achieved.

Herein we present 2D hydrotalcite ($Mg_6Al_2(OH)_{16}(CO_3)•4H_2O$; HTC) nanoporous materials for high selectivity of silica ions from high value waters. Our data shows that calcined amorphous HTC removes >90% silica from batch solutions as compared to uncalcined HTC due to the active ion exchange sites on both the edges and internal layers. However, the act of calcining the Si/HTC enables the regeneration of the material for multiple use recycle; crystallographic data indicates the calcination allows for additional ion exchange site exposure in each cycle. Materials characterization studies indicate that in the calcined HTC, the silica anions primarily have strong attraction to the edge sites of the layered materials, with secondary attraction to the internal layer exchange sites. Furthermore, the HTC effectively removes silica from cooling tower water (CTW), even in the presence of large concentrations of competing anions, such as Cl^-, NO_3^- HCO_3^-, CO_3^{2-} and SO_4^{2-}. The Single Path Flow Through (SPFT) tests confirmed to rapid uptake of silica by HTC during column filtration and an overall uptake capacity of ~ 45 mg SiO_2/g HTC. The experimental data of silica adsorption fit best to Freundlich isotherm model. Materials characterization included Fourier transform infrared (FTIR), Thermogravimetric-Mass analyses (TGAMS), Energy dispersive spectroscopy (EDS) and powder X-ray diffraction (XRD). Techno-economic analysis and scale-up studies will also be presented.

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