Combining gas hydrate and crosslinked chitosan to remove Cr(VI) from wastewater

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The application of gas hydrates for water treatment, especially desalination, has been explored for six decades. However, current technologies focus on the promotion of the gas hydrate formation and do not consider the treatment of the remaining highly contaminated solution. In the framework of our project “ECO-Efficient CO_2 capture from exhaust gases and coupled treatment of industrial wastewater using gas hydrate technology”, we aim to combine the removal of CO_2 from exhaust gases as well as the clean-up of wastewater from industrial facilities in a single step via gas hydrate technology and with a particular focus on the use of suitable adsorbents. The research contributes to the Sustainability goals number six clean water and sanitation as well as number 13 climate action. Wastewater containing toxic heavy metals such as Cr(VI)-ions and an exhaust gas containing CO_2 resulting in a gas hydrate phase containing mainly CO_2 and water molecules, whereas the toxic contaminants accumulate in the remaining aqueous phase. To remove the toxic components from this enriched phase, an adsorbent (hydrogel) is added to the aqueous phase before hydrate formation. This adsorbent may also promote the formation of gas hydrates.
To produce these hydrogels, chitosan (> 75 % deacetylation) was mixed with different amounts of terephthalaldehyde (TTA) to determine the influence of the amount of crosslinker in the materials. The swelling ratio decreases with an increasing TTA concentration. The point of zero charge is between 4.5 and 5.5. The hydrogels are stable at pH 3 and higher. The Cr(VI) adsorption does not depend on the pH. The equilibrium concentration can be reached after 30 to 60 minutes and a maximum of 815 µg of Cr(VI) can be adsorbed (40 mg of crosslinked chitosan, c(CrO_4^{2-}) = 1 g/L, V = 2 mL). Cr(VI) adsorption decreases by increasing concentration of other ions (e.g. chloride, nitrate and sulfate). Finally, upon treatment with Cr(VI)-containing solution, all materials show a color shift from yellowish/brown to green. This indicates the (partial) reduction of Cr(VI) to Cr(III), but this will be verified with X-ray photoelectron spectroscopy (XPS) soon. Future experiments will investigate if these materials also promote gas hydrate formation and at the same time improve chromate removal from aqueous solution.

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