Synergistically improved adsorption of anionic surfactant and crystal violet on chitosan hydrogel beads

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While a plethora of gel beads have shown to exhibit excellent adsorbent properties, biogel beads are more attractive because of their diverse nature and biocompatibility. To this regard, chitosan hydrogel beads, where ‘synergistic effect’ plays a significant role in the efficiency of adsorption, have shown great promise. The normal adsorption rate of sodium dodecylsulfate (SDS) on chitosan hydrogel beads is greatly enhanced in presence of crystal violet (CV) dye. In such situations, simultaneously enhanced adsorption rate for both the adsorbates (viz., SDS and CV) are observed. This synergistic adsorption on a hydrogel, chitosan is being reported herein, to the best of our knowledge, for the first time. Underlying ionic interaction between the cationic part of the dye and the anionic head group of the surfactant molecule already embedded in the chitosan gel bead makes this synergism possible. The adsorption of SDS on chitosan hydrogel beads is studied in detail. The ionic interaction is manifested in the pseudo-second order kinetics of SDS removal by chitosan beads. In this article, we report our findings of quantitative analyses on SDS adsorption via the study of Langmuir adsorption isotherm ($Q_{\text{max}} = 76.9 \text{ mg g}^{-1}$). Desorption studies are performed on chitosan gel beads after simultaneous adsorption of CV and SDS. Interestingly, the gel beads desorb the CV up to $\sim 47\%$ on long standing, leaving aside SDS in the beads. This authenticates selectivity in the desorption process. In an effort to develop eco-friendly processes implementing 'zero waste' management strategies, we find that the dye can be recovered quantitatively from the beads with acetone.

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1. Introduction

Surfactants constitute a very important group of compounds in modern life. They are present in a large variety of products like soaps, detergents, pharmaceuticals, and personal care products. They also have extensive use in various industries such as textile, fiber, paint, polymer, oil refinery, and pulp-paper. Many industries also use dyes as coloring agents. As a consequence, in many industrial wastewaters the co-occurrence of both surfactant and dye is observed. The use of surfactants in the world is increasing day by day from 1.7, 1.8 to 9.3 million tons in the years 1984, 1987 and