



Aggregation and deposition of colloidal particles: Effect of surface properties of collector beads

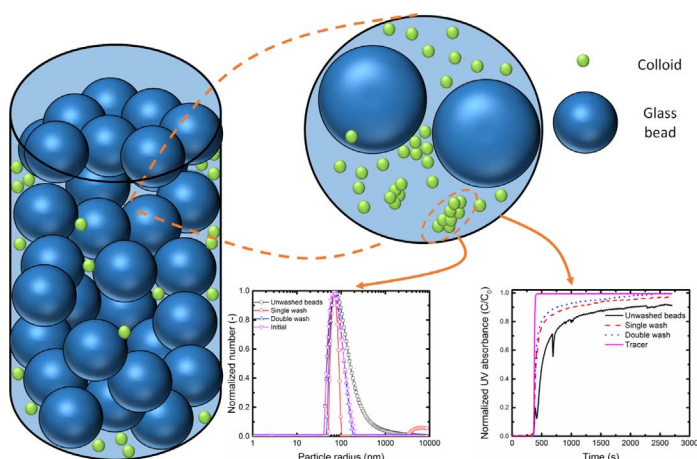


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GRAPHICAL ABSTRACT

The change in the surface chemistry of collector beads after washing affects their surface charge, colloid–colloid and colloid–collector interactions, and subsequently the concurrent aggregation and deposition of colloidal particles.



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ABSTRACT

The effect of the surface properties of collector beads on the transport of colloidal particles in porous media has been experimentally investigated. Both batch and continuous column experiments were conducted to study the dynamics of deposition and aggregation of colloids (polystyrene latex sulfate, $d = 100$ nm) in contact with collector particles (soda lime glass beads, $d = 212$ – 300 micron). Various rinsing methods were systematically used to wash the surface of soda lime glass beads. Time-resolved dynamic light scattering (TR-DLS) and ultra-violet-visible spectroscopy (UV–vis) were employed to evaluate the concentration of colloidal particles and their aggregation in columns packed with glass beads. Rinsing of glass beads was found to release the surface ions of collectors into the colloidal suspension and subsequently led to the aggregation of colloids. In batch experiments, leaching-induced increase of ion concentration in the suspension triggered the aggregation process, while, the collision frequency governed the aggregation dynamics later on. In column experiments, however, the initiation of aggregation by released ions was dependent on the length of the column. In a long column, a blocking-ripening mechanism was observed at the lower pH that indicated the concurrent aggregation and deposition of colloidal particles. In a short column, however, the concentration of eluted colloids did not decline over time that revealed incapability of leaching process to initiate aggregation. Furthermore, the solution chemistry was realized to be more effective in determining the fate of colloidal particles inside packed columns than the surface

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chemistry of collector beads. This study provides valuable insight into the effect of surface properties of collectors on aggregation and deposition of colloidal particles in a packed environment.

1. Introduction

Transport of colloidal particles through water-saturated environments attracted considerable attention in the last decades owing to its significant role in the human safety and ecological health [1]. This phenomenon occurs in numerous applications including granular filtration, fouling of membranes and heat exchangers, re-deposition of corrosion products [2], and underground transport of contaminants [3].

The effects of influential factors on the transport of colloidal particles in a packed column are still unknown due to its complex nature [4]. In general, the behavior of colloidal particles inside a water-saturated porous medium is mainly controlled by interparticle forces, i.e. colloid-collector and colloid–colloid interactions. Aggregation of colloidal particles, resulted from attractive colloid–colloid interactions, is primarily affected by the chemical properties of colloidal suspension, mainly pH and concentration of electrolyte [5–7]. On the other hand, deposition of colloids on the surface of the collector particles, i.e., porous medium constituents, is the result of attractive colloid-collector interactions [8]. This process is primarily affected by the physicochemical properties of both colloidal suspension, e.g. pH and concentration of electrolyte [9,10], and collector particles, e.g. surface activity [11], charge, and its roughness [12,13].

In general, colloidal particles can deposit on collectors as either individual or aggregated particles. Regardless of the deposition scenario, the condition of collector beads is an influential factor in the

process of colloid transport through confined environment. Most of the porous media constituents, e.g. soil components, are active in the aquatic environment [14]. The corrosion of these surfaces alters the surface forces and thus changes the mechanism of colloidal transport in a porous medium. The corrosion rate mainly depends on the pH variation in the surrounding medium [15]. For instance, the surface soda lime glass beads is de-alkalized in acidic condition, while in the basic environment the dissolution of network silica takes place [16,17]. The surface properties of soda lime glass beads are important due to their widespread application in industry. This type of glasses is predominantly used in food industry as liquid containers. Since they are responsive to any physicochemical changes in the liquid, the quality of food with a considerable amount of colloids in contact with them might be questioned. Furthermore, the dynamic change of the surface chemistry of corrosive collector surfaces, including soda-lime glass beads, affects the surface charge and subsequently the colloid/collector interaction. To date, this complex interplay and its effect on the transport of colloids remained obscure and calls for further investigation.

In this study, we strived to portray the role of surface corrosion and ionic functional groups on the stability of colloidal particles and their deposition inside the porous medium. In this regard, batch experiments were carefully carried out to address the stability of colloidal particles along with column experiments that were performed to understand deposition dynamics of colloids in the presence of these interactive surfaces. Understanding the role of collector surface condition on

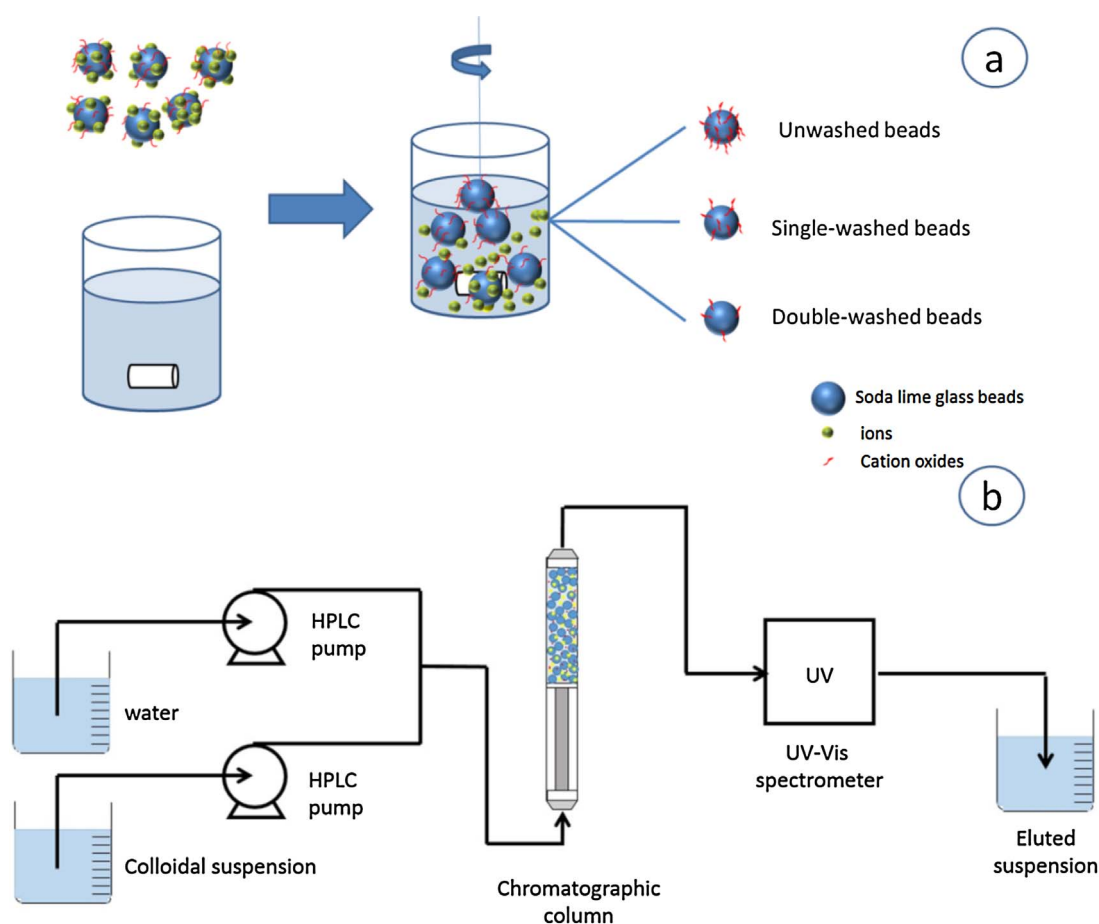


Fig. 1. (a) The process of rinsing the glass beads; (b) Schematic illustration of column experiment.

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