

Organic Chemistry 2018: Developing cation exchange as a viable strategy for nanoparticle synthesis- P Gregory Van Patten

P Gregory Van Patten

Middle Tennessee State University, USA

Semiconductor quantum dots (QDs) are promising materials with interesting, size-dependent properties. Although a few model systems (CdSe, PbS, and some others) have been developed, optimized, and thoroughly studied over the past few decades, there remain several obstacles that prevent their adoption in a variety of applications. One principal challenge is the inability to access a diverse range of QD materials with excellent control over size, shape, crystallinity, and surface chemistry. Control over these QD characteristics is crucial for the production of high-quality materials. Since direct synthetic approaches that afford such control have been elusive, we have been exploring cation exchange (CE) as a route to QDs with new compositions. To make CE a viable approach, it must be scalable, must be widely applicable, and must proceed to completion. Additionally, it is desirable to be able to achieve partial exchanges to produce alloy or heterostructures. I will summarize our progress on these goals to date.

The cation exchange capacity is defined as the positive charge of the quantity that can be exchanged for the mass of the soil, measured in cmolc / kg . Some texts use the old equivalent units $\text{me} / 100\text{g}$ or $\text{meq} / 100\text{g}$. The CEC is a measure of the electrical charge of the moles, so a cation exchange capacity of $10 \text{ cmolc} / \text{kg}$ could contain 10 cmol of Na^+ cations per kilogram of soil, but only 5 cmol of Ca^{2+} (2 charge) units per cation

The cation exchange capacity results from various surfaces of soil particles, especially those of clay minerals and organic matter. Phyllosilicate clays consist of aluminum and silicon oxides of laminated sheets. The replacement of aluminum or silicon atoms with other charges can be a lower charge (for example Al^{3+} replaced by Mg^{2+}) with a net negative charge. This charge does not imply deprotonation and is therefore independent of pH, and is called permanent charge. In addition, the edges of these leaves expose many acidic hydroxyl groups which are deprotonated to negative charges at pH levels and many soils. Organizing matter

also brings a very important economic to the exchange of cations, due to its large number of charged functional groups. CEC is a high near-surface soil, where the depth of the organic matter content is high and decreases. The CEC of organic matter is strongly dependent on pH

Cations are adsorbed to soil surfaces by the electrostatic interaction between their positive charge and the negative charge of the surface, but they retain a shell of water molecules and do not form direct chemical bonds with the surface. Exchangeable cations thus form part of the diffuse layer above the charged surface. The binding is relatively weak, and a cation can easily be displaced from the surface by other cations from the surrounding solution.

Cation-exchange capacity is measured by displacing all the bound cations with a concentrated solution of another cation, and then measuring either the displaced cations or the amount of added cation that is retained. Barium (Ba^{2+}) and ammonium (NH_4^+) are frequently used as exchanger cations, although many other methods are available

Inorganic colloidal nanocrystals (ICNC), because of their tunable optical and electronic properties, are made possible by precisely controlled compositions and morphologies. Recently, many strategies have been reported for direct synthesis of ICNCs, such as hot injection and hydrothermal methods. Although a variety of high quality ICNCs and diverse morphologies have been obtained, high quality ICNCs for limited competence, such as deep site engineering quantum dots (QD), advanced hybrid semiconductor nanocrystals (NC) with hetero-interface engineering and perovskite Stable and adjustable luminescence with NC. The above-mentioned ICNCs have improved nanostructures with a wide range of applications for improved properties, such as the luminescent solar concentrator, photocatalysis, and supercapacitor. To control ICNCs with well-defined heterostructures, many strategies have been developed, such as galvanic replacement,

liquid exfoliation and axial growth. Among these methods, cation / anion exchange reactions (CER / AER) have been developed to formulate compositions and structures with synthesizing ICNCs. Over the past 5 years, doped NCs