NITROGEN-GRAFTED ACTIVATED CARBON FOR REMOVING NITRATE FROM WATER

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INTRODUCTION.

Nitrate (NO_3-) is a contaminant that appears in agricultural runoff water, and in areas that host septic tanks and animal feed lots. Nitrate is released in the urine of humans and animals; and from feed lots and septic tanks, it can migrate into the groundwater. Nitrate and nitrite (NO_2-) are common contaminants in Kazakhstan's surface waters. Thus, they pose an important environmental and health concern throughout much of Kazakhstan. When nitrate exceeds 62 mg/L or nitrite exceeds 4.6 mg/L, they can cause methemoglobinemia in babies, and effectively cause them to suffocate. At present nitrate is removed with ion exchange using polymer anion exchangers. However, this process is expensive and requires much NaCl salt for regeneration. Alternative physicochemical methods such as reverse osmosis, are expensive and inefficient. Therefore, many waters that have high nitrates simply are not used as a water source. This can amount to a considerable loss of a valuable resource in arid climates such as in much of Kazakhstan.

AIMS AND OBJECTIVES.

The proposed research will develop cation- and anion-selective materials based on nitrogen-doped redox-sensitive granulated activated carbon, NGAC, with polypyrrole moieties that can be regenerated electrochemically, and thus will not require concentrated (2 M NaCl) brines for regeneration. Redox-sensitive nitrogen-grafted activated carbons would have a positive charge that attracts nitrate when oxidized, and neutral charge that releases nitrate when reduced. Electrochemical regeneration of NGACs would allow their re-use through multiple cycles in a manner that would be economically and technically practical.

PRELIMINARY RESULTS.

The literature and our preliminary results thus far indicate that the polypyrrole charge can remain stable through multiple redox cycles (at least 50 in the laboratory experiment thus far). This concept mimics key bio-features of hemoglobin, for which each molecule includes four pyrrole moieties. Hemoglobin hosts a million redox cycles of breathing during a human's life. The authors anticipate that likewise, when these NGACs are processing groundwater that contains 40-70 mg/L nitrate, this electrolytic regeneration will facilitate prolonged life for the media, while it undergoes multiple redox cycles of use. The key to the selectivity of the NGACs is achieved by the deposition of N-bearing conductive polymers such as polypyrrole, polyaniline, pyridinium, quaternary ammonium, etc. to the AC surface.

N-bearing conductive films have been extensively explored because of their high conductivity, efficient redox cycling, and ease of synthesis (i.e., electropolymerization). However, significant work is still needed to develop conductive polymer materials that are best suited for removing nitrate, and are robust to multiple redox cycling and anodic oxidizing conditions. It is important that these functional units are supported on granular media such as porous activated carbon that have low water flow resistance and in addition possess substantial adsorption capacity towards other contaminants.

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