Clay Polymer Nanocomposite for Efficient and Rapid Removal of Organic Matter from Water

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INTRODUCTION

Surface water pollution is caused by a wide variety of natural and unnatural substances found in water in different concentrations. **Dissolved organic matter (DOM)** is a mixture of natural molecules found in all surface water sources. At high concentrations, DOM causes an undesirable odor, color and taste and even reacts with chlorine creating harmful substances that affect human health, some are found to be carcinogenic. In water treatment facilities, DOM brings upon several problems, mainly the enhancement of biofilms growth on pipelines and membranes, which impairs the efficiency of the facilities

DOM can be removed using adsorption to a solid substrate. **Activated carbon (AC)** is an industrial sorbent found in most water purification plants. AC has relatively low DOM removal efficiency, slow adsorption kintetics and expensive, complex regeneration process.

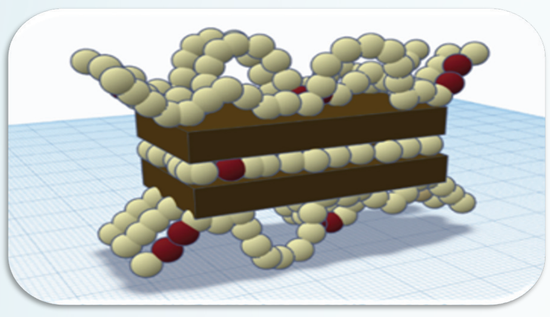

Fig.1 Polymer clay composites model.

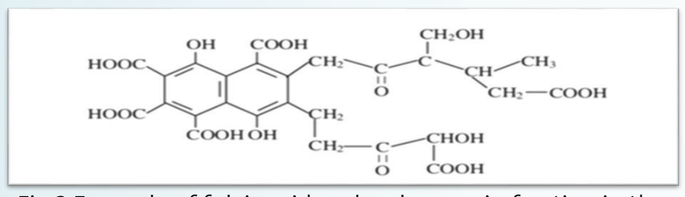

Fig.2 Example of fulvic acid molecule, a main fraction in the DOM. Credit: Wang, S. & Mulligan 2006

One of the most promising alternative sorbent is **clay polymer composite**, a hybrid polymer and clay complexes that characterized with high surface area and fast adsorption kinetics.

RESULTS

A comparison was made between the composite and the most common industrial sorbent, activated carbon.

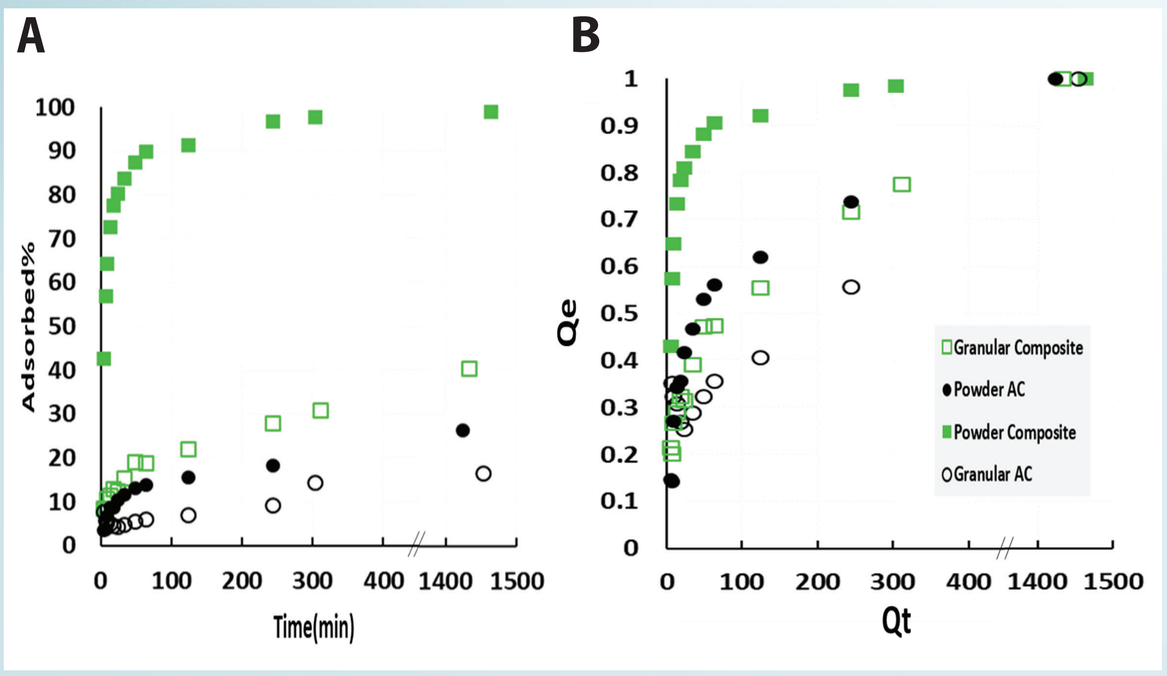

Fig.4 percentage of DOM that was adsorbed as a function of time (a). Pollutant mass that was adsorbed at a given time / Pollutant mass that was adsorbed at equilibrium (b).

Sorbent	Kinetic order	Kinetic constant
Granular composite	second	0.01
Powder composite	second	0.6
Powder activated carbon	second	0.027
Granular activated carbon	-	-

Table.1 Order and constant kinetics of the four sorbents.

In future research, I plan on testing if the regeneration process in a concentrated salt solution is suitable for the composite I have developed. In addition, I would like to improve the granulation process of the granular composite in order to maximize its adsorption potential.

MATERIALS AND METHODS

Preparation and characterization of the composite
The preparation of the composite involved the adsorption of polymer to the clay in order to create a positively charged, hybrid complex. In order to verify the success of the synthesis, tests were performed on various devices. For the purpose of examining the adsorption kinetics, a powder and granular composite was prepared.

The kinetics experiments
Was performed in water tanks containing a pollutant solution into which the sorbent was placed. At known intervals samples were taken from the solution and the DOM concentration in them was measured by a UV spectrophotometer. The experiments were performed in three repetitions on each of the sorbents.

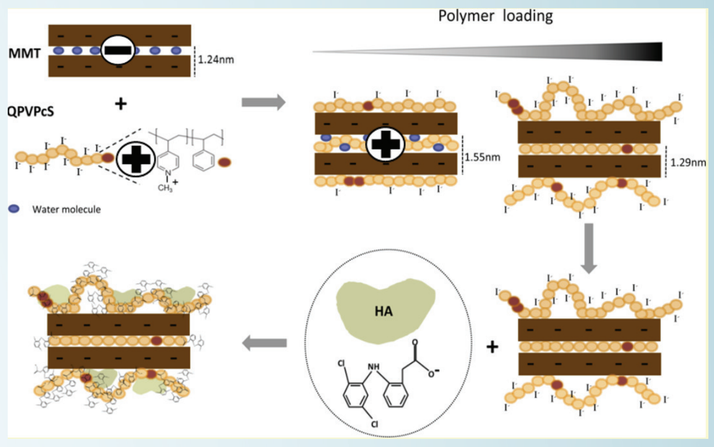

Fig.3 Polymer clay composite production process and adsorption mechanism. Credit: Kohay et al, 2015

Processing the results
The results were processed and adjusted to kinetics orders. kinetics constant calculated using python code and matplotlib library to model the results.

DISCUSSION

The powder composite reached a maximum adsorption of 100% after 4 hours. For all other sorbents and most importantly, the powdered activated carbon it took longer at a lower efficiency (26% removal in the powdered activated carbon) and so despite the similarity in adsorption kinetics we find a clear advantage in the adsorption performance of the powdered composite.

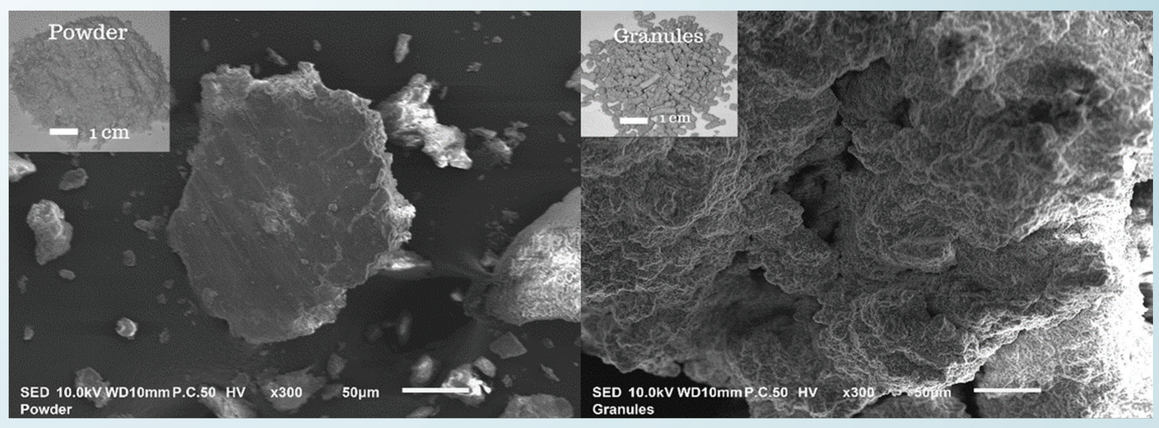

Fig.5 SEM imaging of the granular and powder composite (50 µm resolution).

While the powder composite is characterized by a fairly flat surface area, the granular composite is characterized by a porous, branched surface with cavities that give it an additional porous range, which does not exist in the powder. This fact is the reason for the differences in the adsorption kinetics between the powder and the granules.

APPLICATION

I developed a polymer clay nanocomposite. It has many attractive features, such as:

- High efficiency in removal of DOM
- Fast adsorption kinetics
- A simple, accessible production process
- Inexpensive compared to other sorbents

Thus, this study has shown that clay polymer nanocomposites can be an alternative sorbent for water purification.

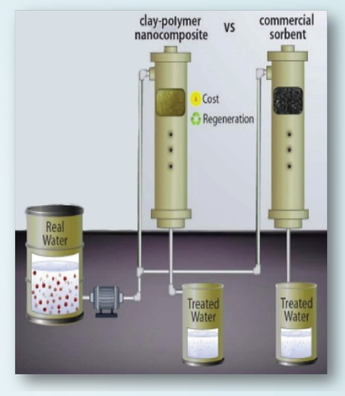

Fig.6 clay polymer composite can be an industrial sorbent. Credit: Shabtai et al, 2021