

Attached phase soil and sediment organic matter (AP-SOM) is of great importance in the transport and retention of engineered nanomaterials (ENM). qCell T provides an exceptional experimental apparatus in studying transport mechanisms of ENM and AP-SOM interactions.

Summary

The role of attached phase soil and sediment organic matter (AP-SOM) in the transport and retention of engineered nanomaterials (ENM) is important and understudied. Using a quartz crystal microbalance (QCM), solution chemistry induced viscoelastic changes in AP-SOM were observed in real time. The sensors were coated with a thin layer of Harpeth River Humic Acid (HRHA) and then the solution chemistry conditions were varied. This technique illustrates the usefulness of the qCell T, a temperature-controlled quartz crystal microbalance, in studying transport mechanisms of ENM and AP-SOM interactions.

Background

Escalating production and subsequent incorporation of engineered nanomaterials (ENM) in consumer products increases the likelihood of release to the environment, where the ecotoxicological impacts remain unknown (Figure 1) [1, 2]. Typically, hydrophobic particulate compounds released over time will accumulate in organic systems, including attached phase soil and sediment organic matter (AP-SOM). Especially in sediments, there is the potential for contaminants to persist for significant periods of time; therefore ENM may impact environments long into the future.

Although some effort has been devoted to investigate the behaviour of ENM in the environment, a very limited number of studies have focused on the interactions of AP-SOM and ENM. In order to understand the interaction between AP-SOM and ENM, we must first understand the properties of AP-SOM. The quartz crystal microbalance provides an exceptional experimental apparatus to characterize these thin films.

Strategy

The QCM allows the measurement of viscoelastic and mass changes within a thin layer of AP-SOM in real time. In this study, electrolyte concentration was varied to induce such changes. Since humic substances typically represent the dominant organic components in soils and sediments [3], a Harpeth River Humic Acid (HRHA) was chosen as a representative AP-SOM.

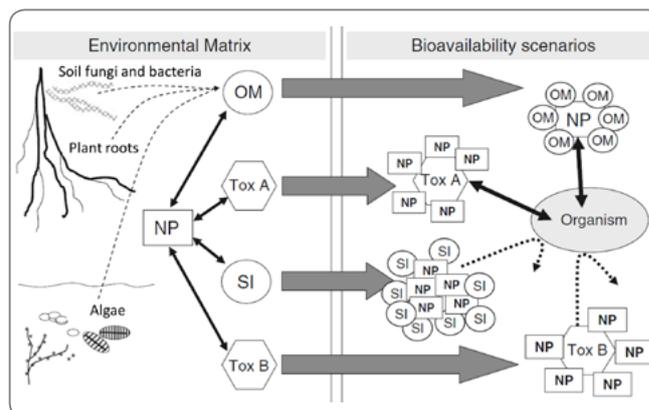


Figure 1. Scenario of nanoparticles' (NP) interactions with toxicants (Tox A and B), salt ions (SI), and organic matter (OM) such as humic acids or compounds released by plants, fungi, bacteria, and algae. Some compounds present in environmental matrices might increase the NP' stability (OM) and thus bioavailability, whereas others (salt ions) might foster the aggregation of NP, thus reducing their bioavailability, or physically restraining NP-organism interactions [2].

Method

The surface of a gold coated 10 MHz QCM sensor is first coated with a layer of positively charged poly-L-lysine (PLL), washed with a buffer solution and then coated with a thin layer of HRHA. Following a wash of the HRHA layer, the HRHA layer is exposed to an order of magnitude increase in electrolyte concentration (from 10mM NaCl to 100mM NaCl). This process is illustrated in Figure 1. The measurement procedure is repeated for NaCl concentrations ranging from 0 and 150mM on each of the 3 surfaces, including the bare gold sensor, PLL and HRHA.

Results

A summary of all the concentrations and surfaces investigated is illustrated in Figure 3. In the frequency signal of Figure 2, it is clear that there are mass changes corresponding to the deposition of each layer, as well as a large, but reversible change corresponding to the increase in electrolyte concentration. The damping signal shows no change throughout the experiment until the in-

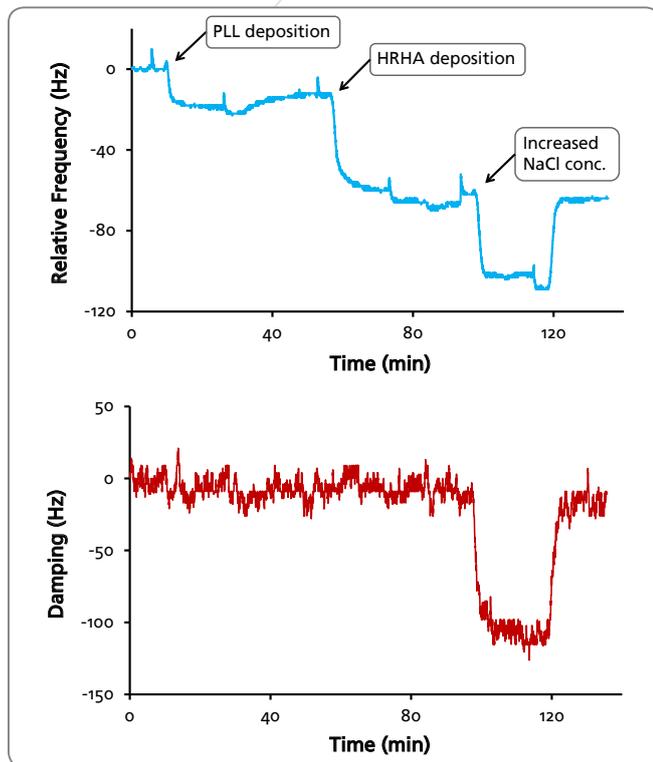


Figure 2. The frequency and corresponding damping changes induced by deposition and changes in electrolyte concentration.

crease in electrolyte concentration, suggesting that there is no significant change in the rigidity of the AP-SOM until the electrolyte concentration is changed and again, this change appears to be reversible. Figure 3 shows that the HRHA layer undergoes the largest change throughout the concentrations investigated.

Conclusion

The QCM represents an advanced and very useful technique to investigate the properties of thin layers and this work illustrates that the QCM can be used to study thin layers of soil organic matter. Since the frequency and damping signals are measured in real time, the QCM can also be used to study adsorption kinetics of ENM to these

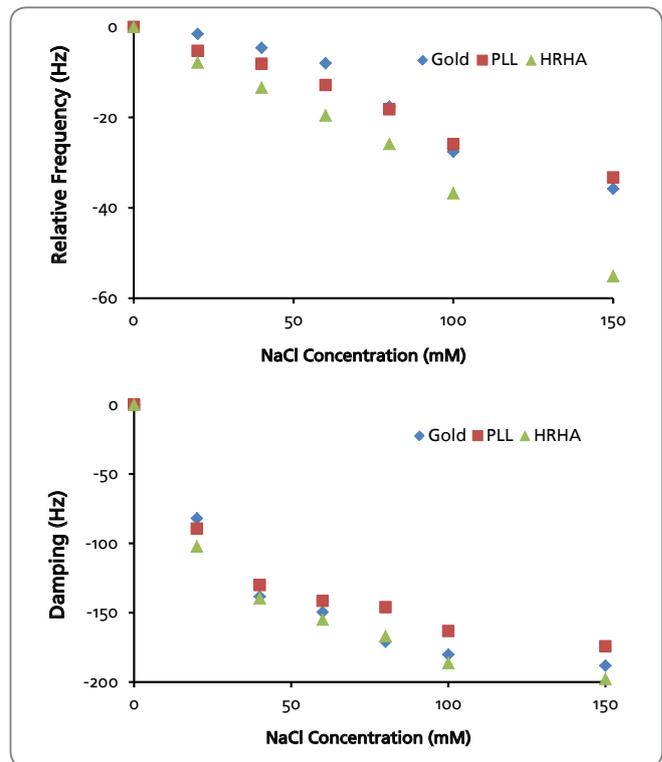


Figure 3. Frequency and damping effects on 3 different surfaces induced by electrolyte concentration changes.

AP-SOM surfaces. This enables improved understanding of how ENM will move through the natural environment.

References

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Acknowledgement

The results were carried out by Coy McNew at Prof. Eugene LeBoeuf's laboratories, University of Vanderbilt, TN USA.