Adhesion attenuation and enhancement in aqueous solutions

Conference or Workshop Item

How to cite:

For guidance on citations see FAQs.

© [not recorded]

Version: Version of Record

Link(s) to article on publisher’s website:
https://www.academia.edu/9823179/Adhesion_attenuation_and_enhancement_in_aqueous_solutions

Copyright and Moral Rights for the articles on this site are retained by the individual authors and/or other copyright owners. For more information on Open Research Online’s data policy on reuse of materials please consult the policies page.
1. Introduction
When two surfaces confine water layers between them at the nanoscale, the behaviour of these confined water molecules can deviate significantly from the behaviour of bulk water, which affects the adhesion of such surfaces. This study assesses the role of confined water layers on the adhesion of hydrophilic surfaces, and how sensitive this adhesion is to the presence of contaminant solutes which can disrupt the hydrogen bonding network of water molecules between the surfaces.

2. Experimental

- Alumina-sputtered sphere-tipped cantilever, interacted versus an alumina single crystal, using atomic force microscopy.
- Solvent/solute concentrations tested over the range 0-100% organic.
- Measurements were performed under immersed conditions using (i) water, and mixtures of (ii) water/dimethylformamide, (iii) water/ethanol, and (iv) water/formamide.

3. Results

\[ W_{th} = -AR/6D \]
\[ A = \frac{3}{4} kT \left( \frac{e_1 - e_3}{e_1 + e_3} \right)^2 + \frac{3h\nu_e}{16\sqrt{2}} \left( \frac{n_1^2 - n_3^2}{n_1^2 + n_3^2} \right)^{3/2} \]

- The measured work of adhesion upon separation of the surfaces was greatly in excess of the theoretical value, \( W_{th} \), predicted by Eq. 1, assuming \( D = 1 \) nm.
- Low concentrations of dimethylformamide and ethanol increased the work of adhesion to values greater than the work of adhesion measured in water.
- Formamide and dimethylformamide exhibited differences in behaviour at high concentrations and for pure liquid.

4. Conclusions

- The number of water molecules in the primary solvation shell is important at low solute concentrations.
- Continuum theories describing adhesion between surfaces are not applicable when hydrogen bonding effects occur.
- When the two surfaces are at closest approach, the structure of the hydrogen bonded network requires further experimental and theoretical consideration.

Acknowledgements
The atomic force microscope used in this research was obtained through Birmingham Science City: Innovative Uses for Advanced Materials in the Modern World (West Midlands Centre for Advanced Materials Project 2), with support from Advantage West Midlands (AWM) and partly funded by the European Regional Development Fund (ERDF).