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Characterization of diatom adhesion properties on different substrates : from population to individual scale

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CONTEXT

Phototrophic biofilms are essential ecological players acting at the interface between the water column and immersed substrates. They are complex aggregates of microorganisms among which diatoms often dominate. These microalgae produce copious amount of extracellular polymeric substances (EPS) which provide a physical structure to the biofilm community (i.e. matrix). To date, little is known about the cell surface properties governing the adhesion of these organisms. Here we used atomic force microscopy (AFM) to decipher the topography and adhesive properties of the freshwater diatom *Nitzschia palea* at the nanoscale.

APPROACH

AFM-based methodologies (figure 1) were used on a non-axenic culture of the benthic diatom *N. palea* in order to:

- image samples in physiological conditions (figure 2),
- compare *N. palea* adhesion on hydrophobic and hydrophilic surfaces using single-cell force spectroscopy (SCFS: figure 3),
- quantify the hydrophobic/hydrophilic balance of the cell surface and map the distribution of EPS using chemical force microscopy (CFM: figure 4).

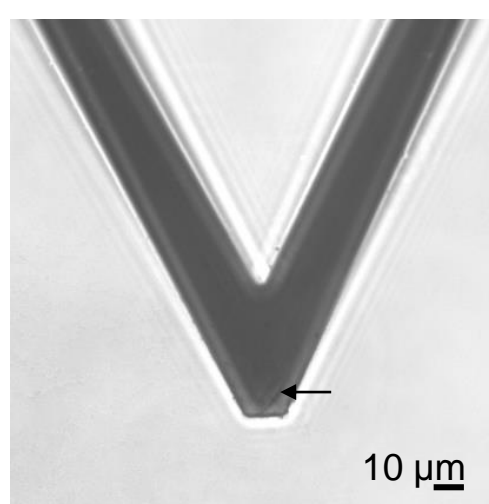


Fig. 1: a cell attached to the AFM cantilever.

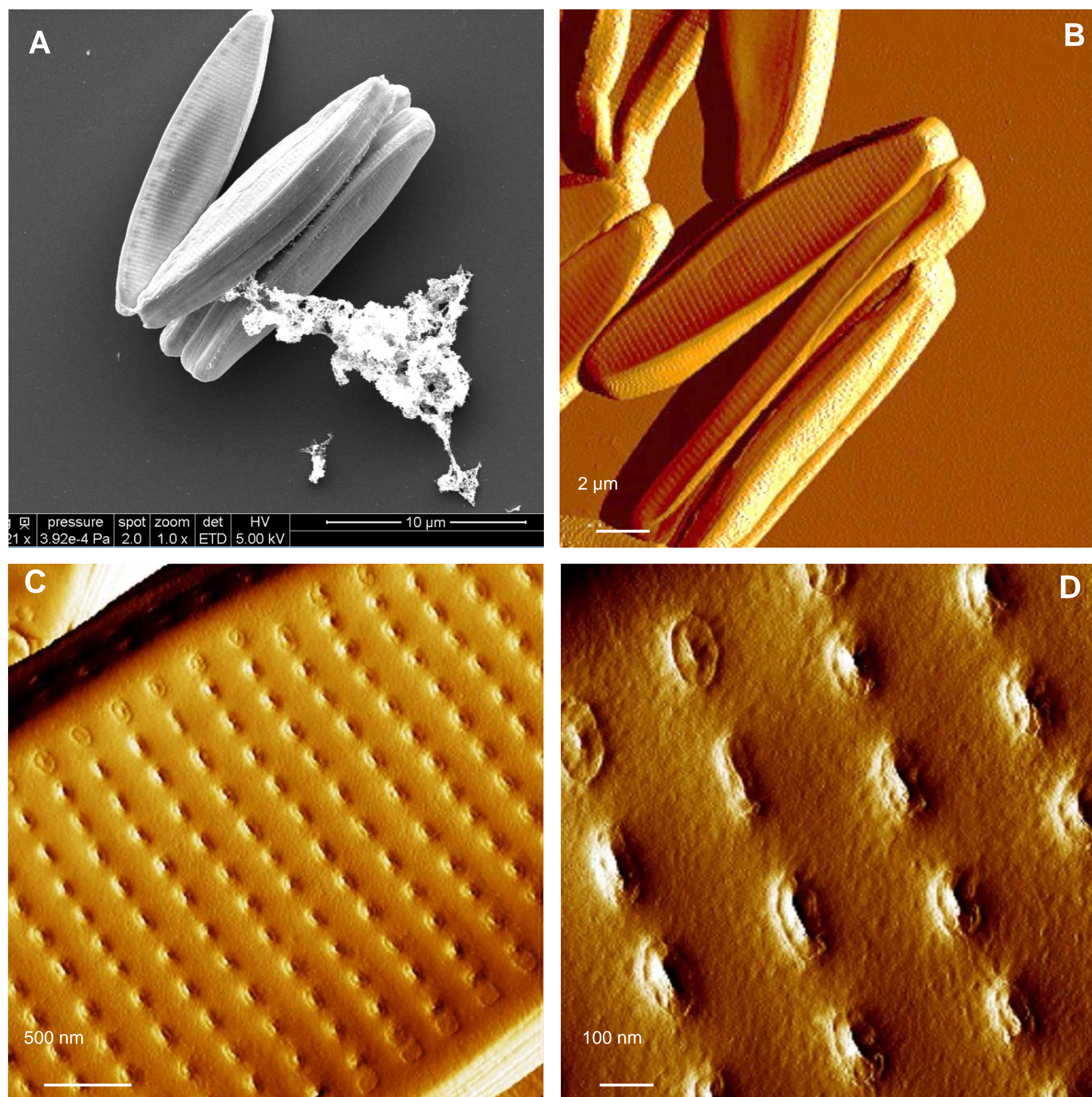


Figure 2: Classical scanning electron microscopy- (SEM-, A) and AFM-imaging in liquid medium (B-D) revealing *N. palea* ultrastructure of the frustule at the nanometer scale,

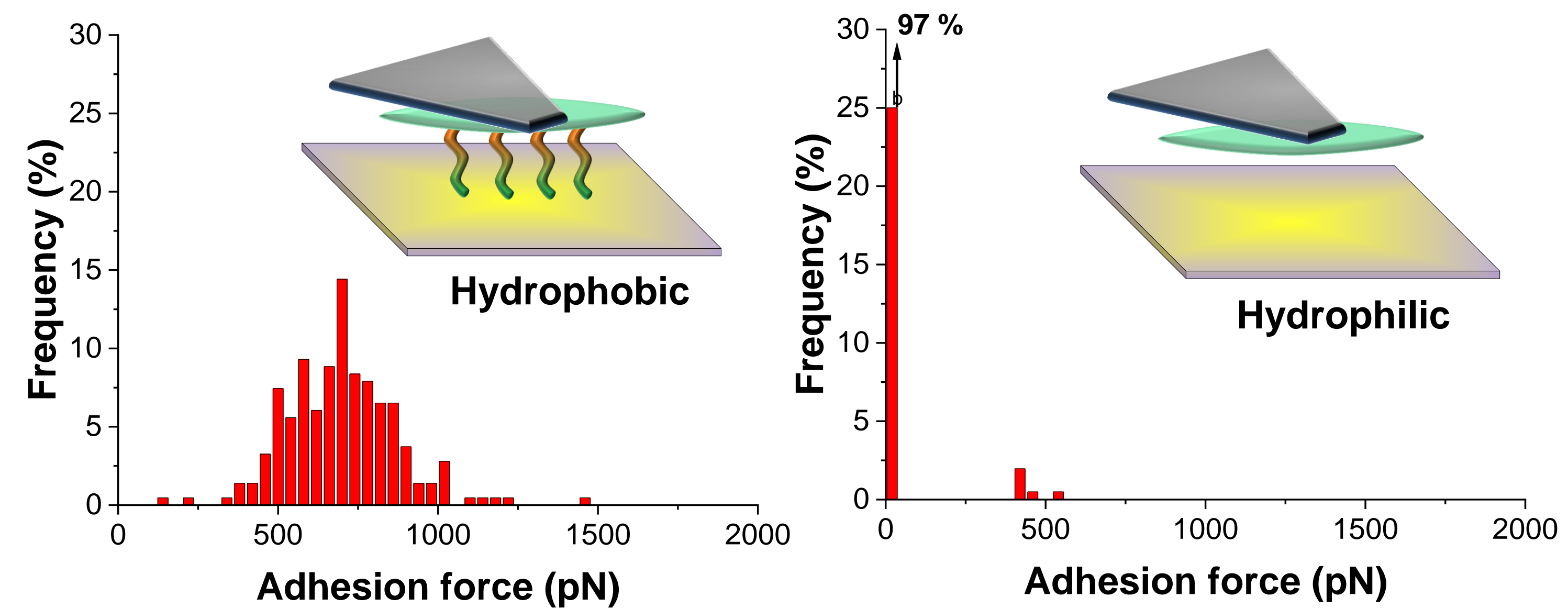


Figure 3 (single-cell analysis): Force histograms of maximum adhesion between a single *N. palea* cell attached on the cantilever and surfaces functionalized with hydrophobic (CH₃, left panel) or hydrophilic (OH, right panel) groups,

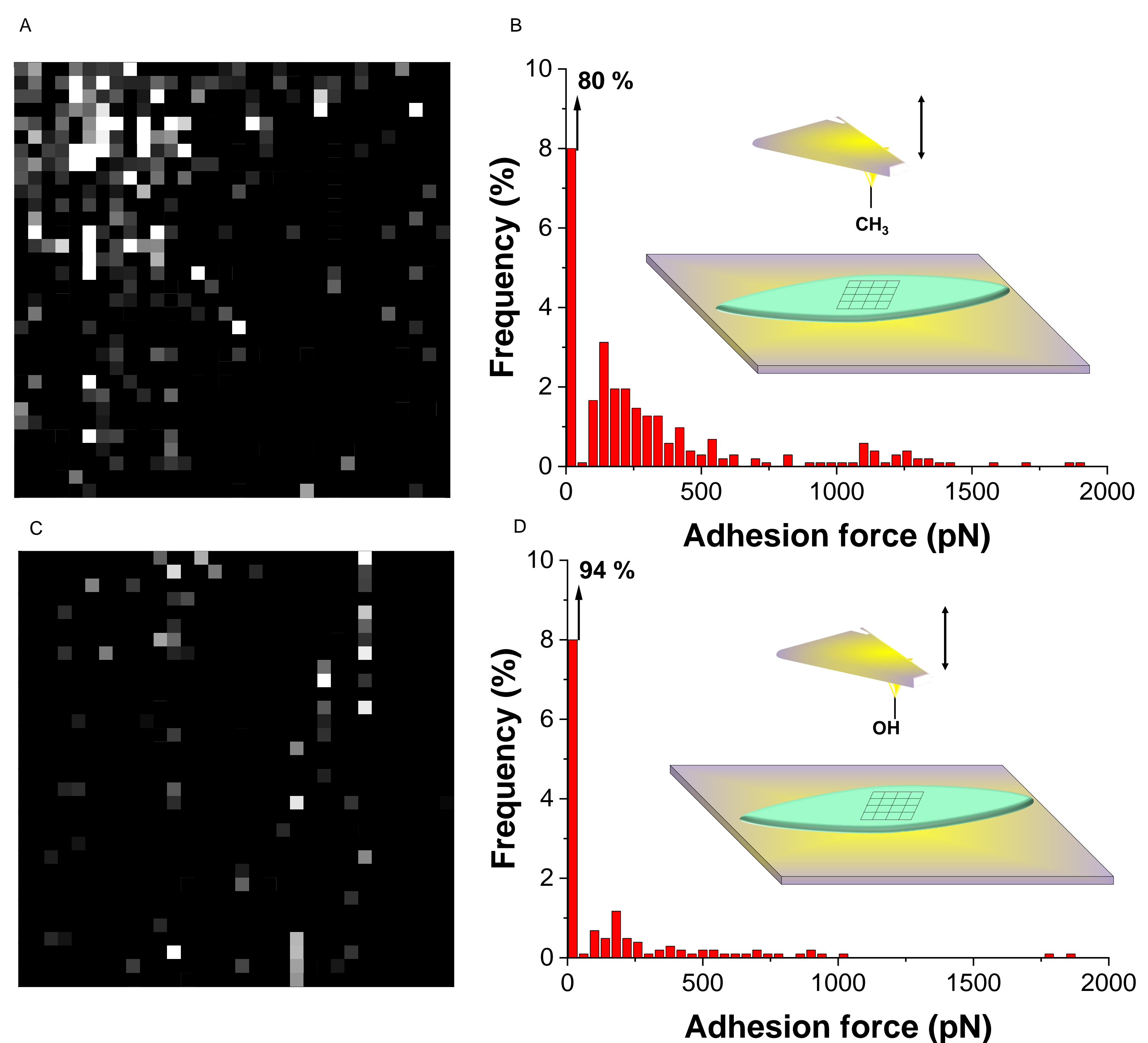


Figure 4 (single-molecule analysis): Adhesion force maps (2 x 2 µm; z range = 1 nN) recorded with hydrophobic (A) or hydrophilic tips (C) at the surface of *N. palea* cells maintained in liquid medium and corresponding last rupture peak histograms (B, D)

MAIN RESULTS

Imaging: *N. palea* ultrastructure was resolved at a spatial scale comparable to classical SEM (figure 2).

Single-cell analysis: *N. palea* adhesion was stronger on hydrophobic surfaces than on hydrophilic ones (figure 3).

Single-molecule analysis: *N. palea* adhesion was governed by surface-associated hydrophobic polymers (EPS), which were not homogeneously distributed on the frustule surface (figure 4).

CONCLUSION AND PERSPECTIVES

- ⇒ Our results demonstrate that **AFM is a powerful platform to decipher diatoms surface properties**, confirming observations obtained at the population level (short-term adhesion bioassays using optical microscopy)
- ⇒ **Adhesion properties will be confronted to EPS composition** (quantity and quality) which varies with environmental factors (light, temperature...) which in turn may influence their ecological roles including adhesion and cohesion of the biofilm
- ⇒ **Other model species of benthic diatom**, exhibiting contrasted patterns of adhesion and/or cohesion will be studied.
- ⇒ These results will help us to better understand the **role of EPS in shaping benthic diatoms biofilm at micro-habitat scale**, which is known to affect its functioning at a larger scale

