MAGNETIZATION OF COLLOIDAL PARTICLES: FROM SILICA MICROSPHERES TO DIATOM FRUSTULES.

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Selective magnetization greatly simplifies particle separation and purification in many bioanalytical applications[1,2]. In particular, magnetization may be helpful in separation of mature diatom frustules from immature ones, hidden inside algal cells. This separation is extremely important for understanding mechanisms of biosilification, particularly by providing opportunity to analyze a proteome, associated with growing frustules. In this work, we suggest a simple but effective way of particle magnetization, and apply this method to magnetization of diatoms.

Fe_3O_4 nanoparticles with average diameter ca. 3-4 nm is probably the most easily available superparamagnetic material. These nanoparticles are commercially available as "ferrofluids", can be easily synthesized by alkaline hydrolysis of ferrous and ferric salts as we did in this work, or prepared in micelles if greater homogeneity is desired[3].

We found that these particles can be effectively immobilized on nearly any surface, pretreated with mercapto/aminoalkyltriethoxysilanes or with polyamines, e.g. polylysine, polyethileneimine, polyallylamine, polyvynilamine. These surfaces include one of polystyrene and silica microspheres, metal colloids and diatom frustules (Figure 1).

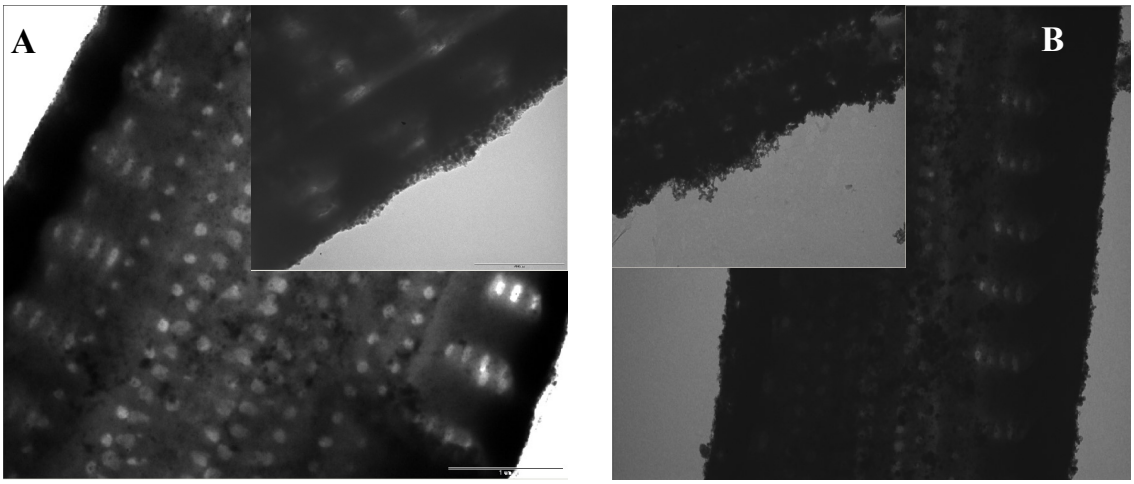

Figure 1. TEM. Frustules of *Synedra acus* pre-treated by polyvinylamine (A) and polyallylamine (B) and coated my by Fe_3O_4.

The magnetized particles have bright brown color and respond well to magnetic field. Although immobilization of the magnetic particles occurs only on the surface, the resulting content of Fe_3O_4 is good – a single step magnetization of 0.5 um microspheres provide particles with 5-7% of Fe_3O_4 by mass. The magnetization steps can be repeated to increase the content of magnetic material, but the single step magnetization is sufficient for magnetic separation. In particular, any of the above mentioned particles can be effectively removed from a suspension by stack of 1 mm–thick neodymium magnetic disks separated by 1 mm wire-based spacers.

Magnetized diatoms can be broken using rotary homogenizer at 1500 rpm without noticeable loss of the magnetic material. Unfortunately, such cell disruption mostly breaks needles of Synedra acus without separation of thecae, hence rarely releases immature frustules. However, after magnetic depletion of the resulting debris some bare, totally Fe_3O_4 – free

particles can be observed (Figure 2B, C). These particles probably were hidden inside the cells at the magnetization step and likely correspond to immature frustules or girdle bands.

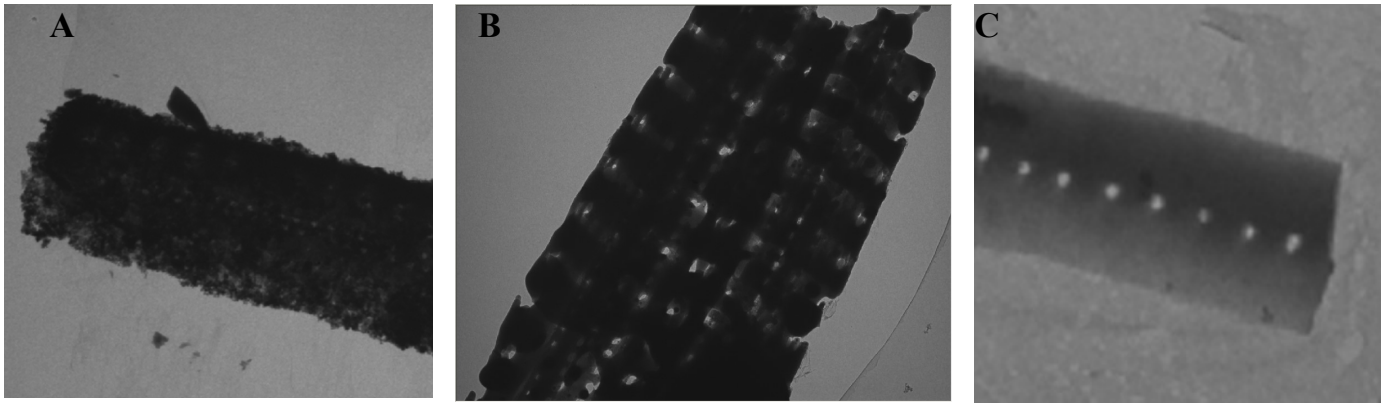

Figure 2. TEM. A: Magnetized diatom frustule. B, C: Bare frustule/girdle band protected from magnetization.

The described magnetization approach, due to simplicity and good efficiency, may be useful in various applications, requiring preparation of magnetic colloids, or in separation of surface-exposed particles from surface-protected ones.

Magnetization of diatoms exhibit good density and stability of the magnetic coating, and allows for the selective removal of surface-exposed frustules. Further optimization of cell disruption, such as application of shear-force in high pressure capillaries, combined with enzymatic pre-treatment, may allow for extraction of immature frustules using this magnetization technique.

References:

1. H. Iida et al. 2006 *Anal. Bioanal. Chem*. 384-3 593-600
2. J. Dobson et al. 2008 *Int. J. Nanomed.* 3(2) 169-180
3. Y.K. Kim et al. 2007 *Mat. Lett.* 61 3124–3129