

Magnetic colloids and molecular diagnostics

Lecture 10

Ferrofluids: Stability against flocculation*

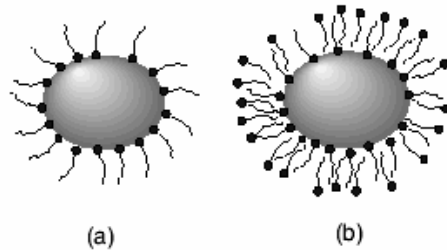


FIG. 1: Sketch of surfacted ferrofluid grains: a) single-layered grains; b) double-layered grains.

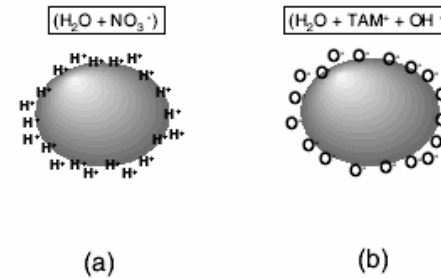


FIG. 2: Sketch of ionic ferrofluid grains. The counterions and the water molecules are also indicated: a) acid ferrofluid grain; b) alkaline ferrofluid grain, TAM⁺OH⁻ is the tetramethylammonium hydroxide.

Diameter to avoid magnetic agglomeration where M is the “intensity of magnetization”

$$d \leq \left(\frac{72kT}{\pi\mu_0 M^2} \right)^{1/3}$$

For MnFe_2O_4 , magnetic moment is $10^{-19} \text{ A}\cdot\text{m}^2$ and the Hamaker constant about 10^{-19} J .

*Scherer, et al.

Attractive potential for magnetic particles

The average interaction energy of identical magnetic spheres with magnetic moment, μ_{mag} , in a liquid with a magnetic permeability, μ_0 , is

$$U(r) = -\frac{2kT}{3} \frac{\mu_{mag}^4}{(4\pi\mu_0)^2} \frac{1}{r^6}$$

The magnetic moment is related to the saturation magnetism and particle diameter as

$$\mu_{mag} = \frac{\pi^{0.5}}{48} M_{sat} d^3$$

For Fe_3O_4 , M_{sat} is 0.45 T

kT = Boltzmann factor

r = distance between particles

$\mu_0 = 4\pi \times 10^{-7} \frac{W}{A-m}$ permeability of free space

d = particle diameter

T, the Tesla, is a Weber per square meter.)
See also Nelson, 1988.

Mixed, charged suspensions with magnetic particles

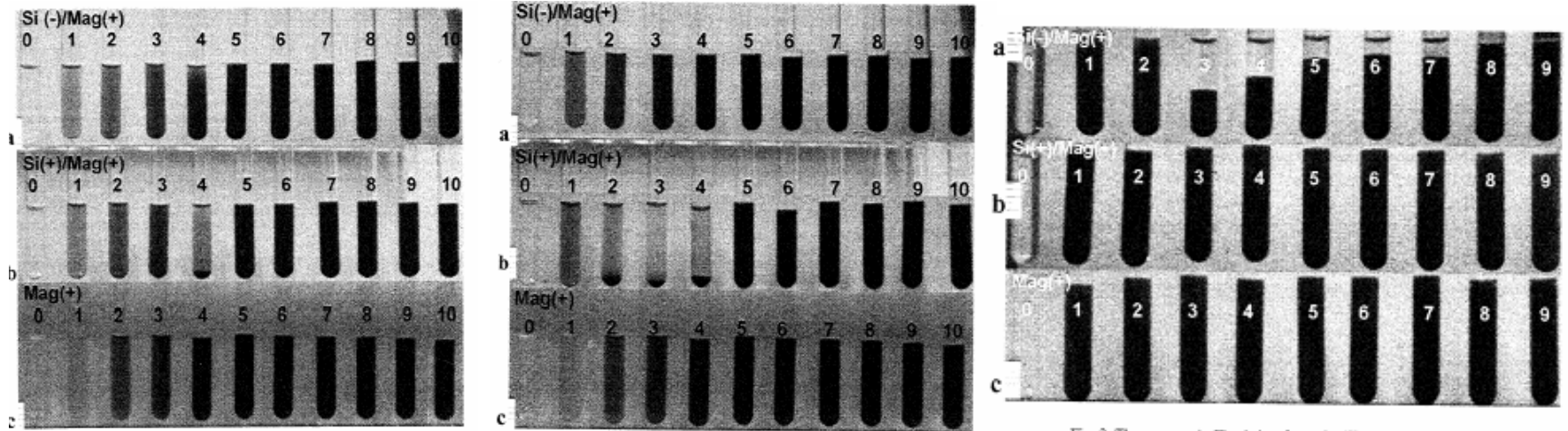


Fig. 2. The same as in Fig. 1, but for series II (see also Table 1).

Fig. 3. The same as in Fig. 1, but for series III (see also Table 1).

Images of mixed suspension taken after 2 weeks. (a) Negative silica – positive magnetite, (b) positive silica – positive magnetite, (c) magnetite diluted with water.

- Normally, oppositely charged particles heteroaggregate and precipitate. (Kim and Berg, 2000) However, adhesion of small particles on larger ones may stabilize the dispersion. (Uricanu et al, 2001)

Viota, et al., 2005.

Capture of viruses*

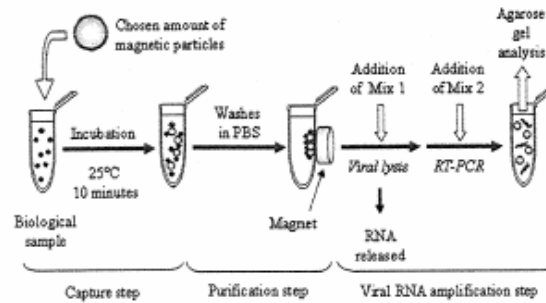


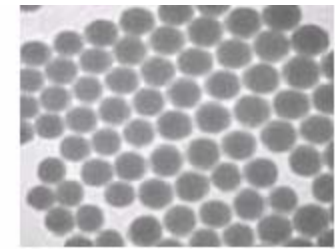
Fig. 8. Protocol of capture of viruses.

Nonaqueous dispersion

10 nm or so magnetite particles are dispersed in hydrocarbons. The colloidal particles are ferromagnetic and the suspension is superparamagnetic.

This ferrofluid is dispersed into water with a nonionic surfactant (e.g. Triton X-405).

O/W emulsion



300 nm magnetic emulsion

$\zeta = -38mV$

Adsorption of a cationic produces a positively charged dispersion.

$\zeta = 34mV$

Adsorption of an anionic and cross-linking produces a negatively charged dispersion.

$\zeta -33mV$

These used to to capture yellow fever virus.

Magnetic colloids: A review

Elaissari, 2005.

Make the carriers:

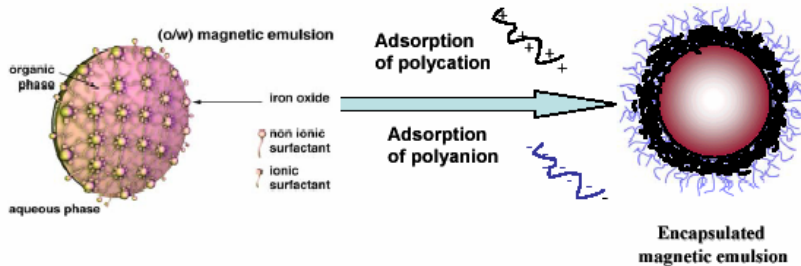


Fig. 3. Layer-by-layer encapsulation process of magnetic emulsion using oppositely charged polyelectrolytes [30]

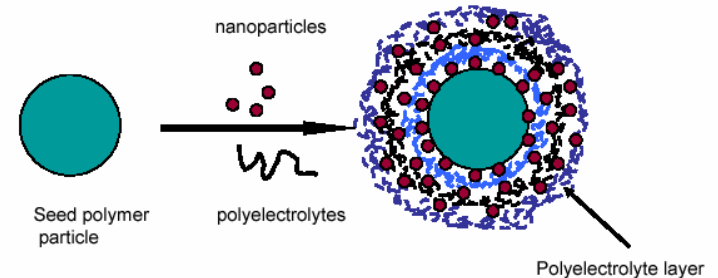


Fig. 4. Layer-by-layer adsorption process of iron oxide and polyelectrolytes onto seed latex particles [32]

Detect the target:

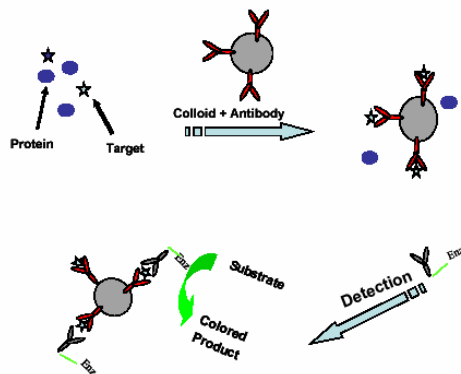


Fig. 6. Schematic illustration of the specific capture and detection of targeted antigen

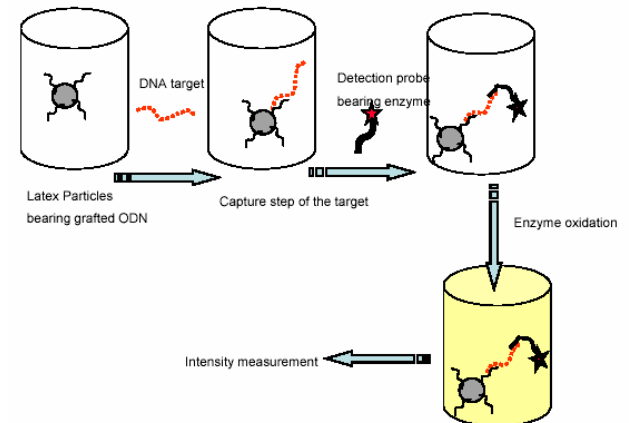


Fig. 7. Schematic illustration of the specific capture and detection of targeted DNA or RNA (ELOSAs, enzyme-linked oligo-sorbent assay) [19]

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