Synthesis of Magnetic Polymer Microspheres for Bio-Medical Applications

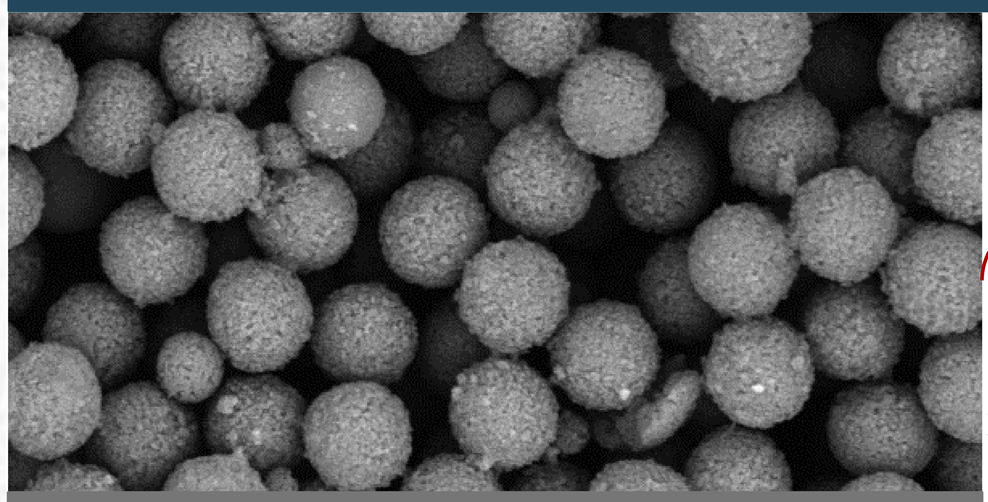
BORESKOV INSTITUTE OF CATALYSIS
Novosibirsk State University *THE REAL SCIENCE

D.O. Shestakova [1,2], N.N. Sankova[1], E.V. Parkhomchuk[1,2]

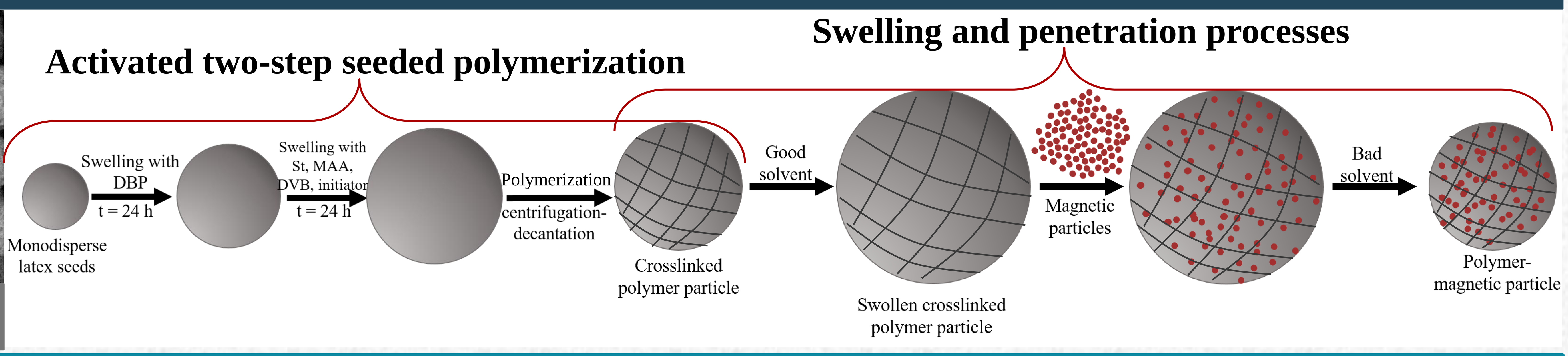
1 – Boreskov Institute of Catalysis SB RAS, 5 Lavrentieva St., Novosibirsk 630090, Russia
2- Novosibirsk State University, 2 Pirogova St., Novosibirsk 630090, Russia
E'mail: shestakova@catalysis.ru

ASAM 8 NOVOSIBIRSK 2023 3 - 7 JULY

Goal and Method of synthesis of magnetic polymer microspheres

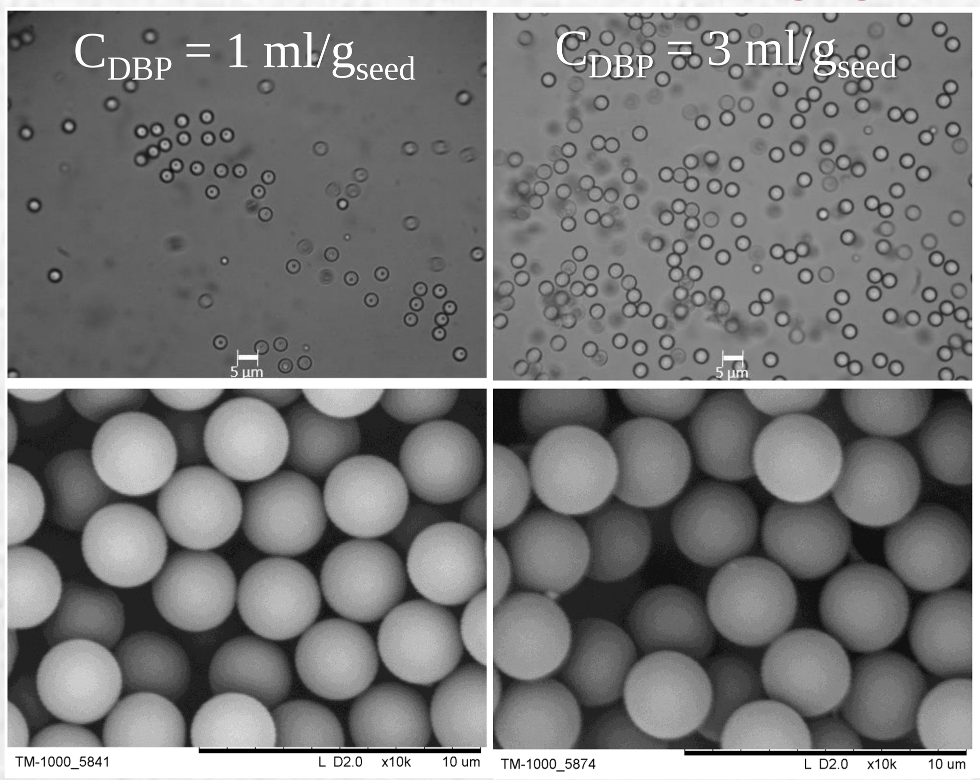


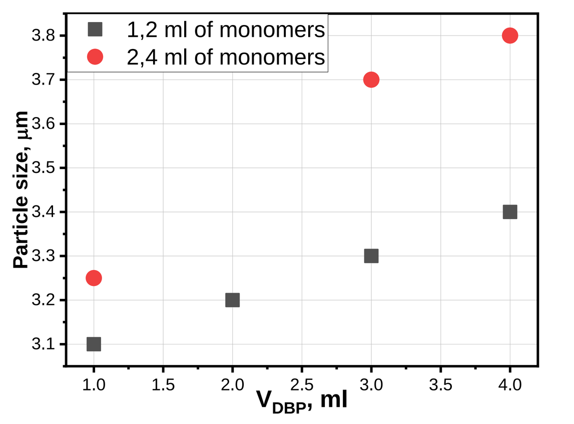
Polymer-magnetic particles for immunofluorescence analysis



Activated two-step seeded polymerization

Effect of swelling agent concentration

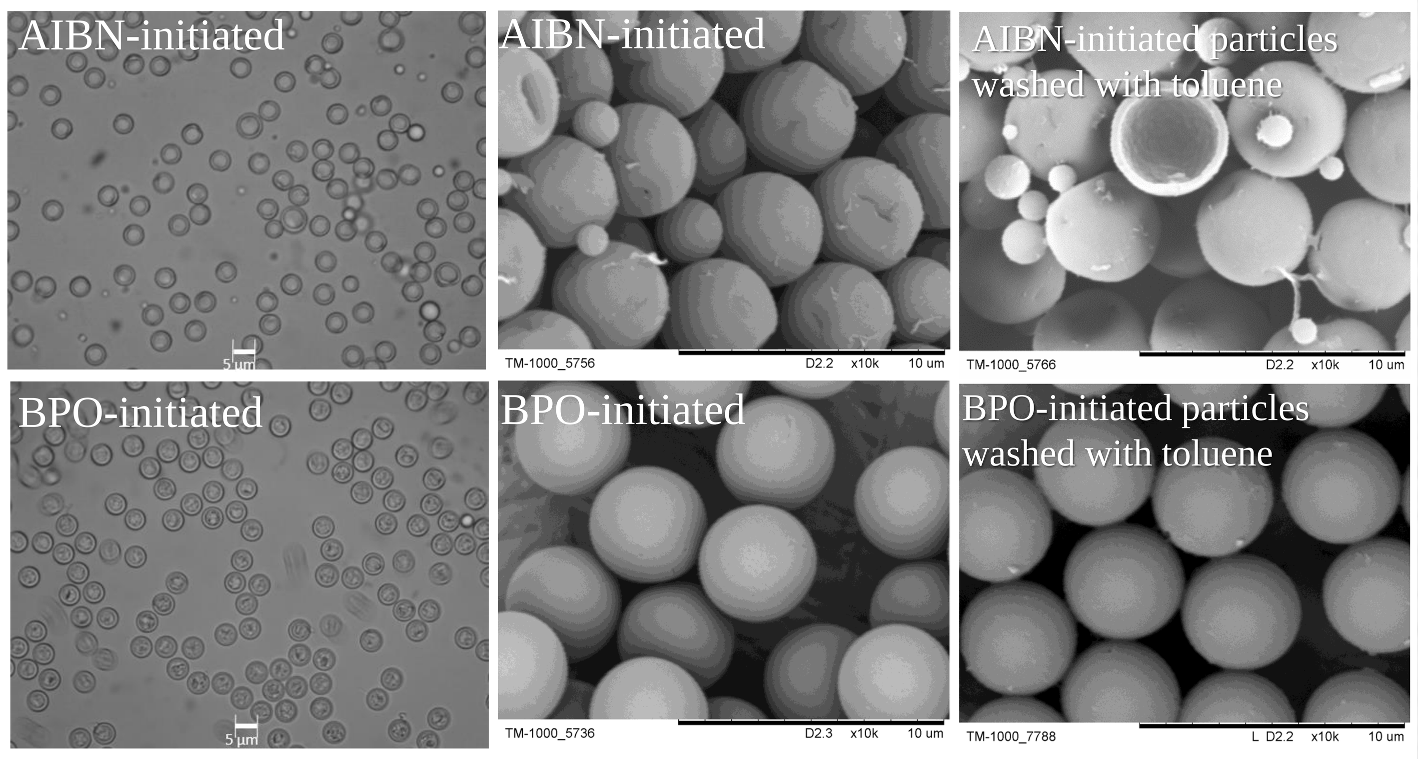




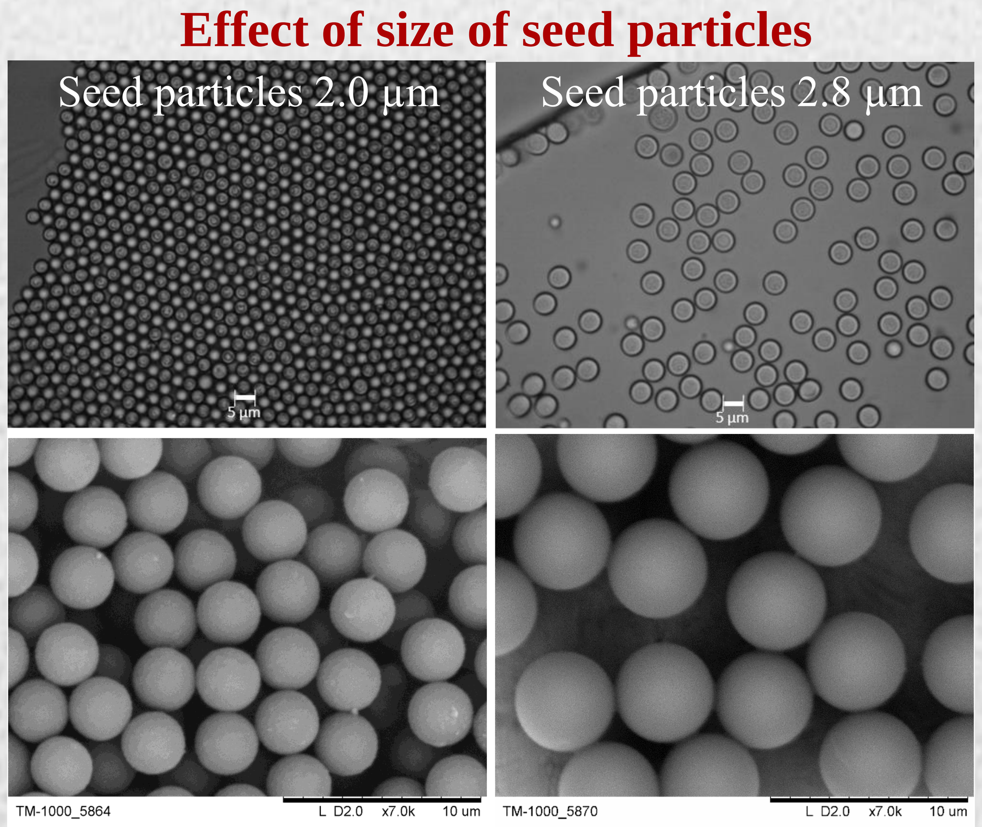
The median particle size increases with the DBP concentration. In addition, the particle morphology also changes. At lower DBP concentration, there is a defect in the interior particle structure observed in the optical microscopy images. This may suggest a more homogeneous distribution of the monomer phase inside the particle, due to the larger amount of monomer introduced, diffusion of which is facilitated in the presence of larger amounts of DBP.

Effect of initiator type

Given that AIBN is more water soluble than BPO (10^{-2} wt. % for AIBN, 10^{-4} wt.% for BPO), it is plausible to suggest that the polymerization primarily takes place at the surface of the particles, resulting in the formation of a shell structure around the polystyrene seed microsphere. When exposed to toluene, the shell can crack, leading to the removal of polystyrene core from the center and the formation of hollow, half-spherical shells.

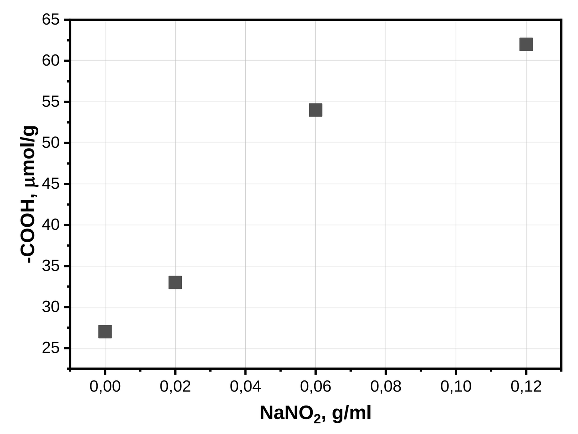


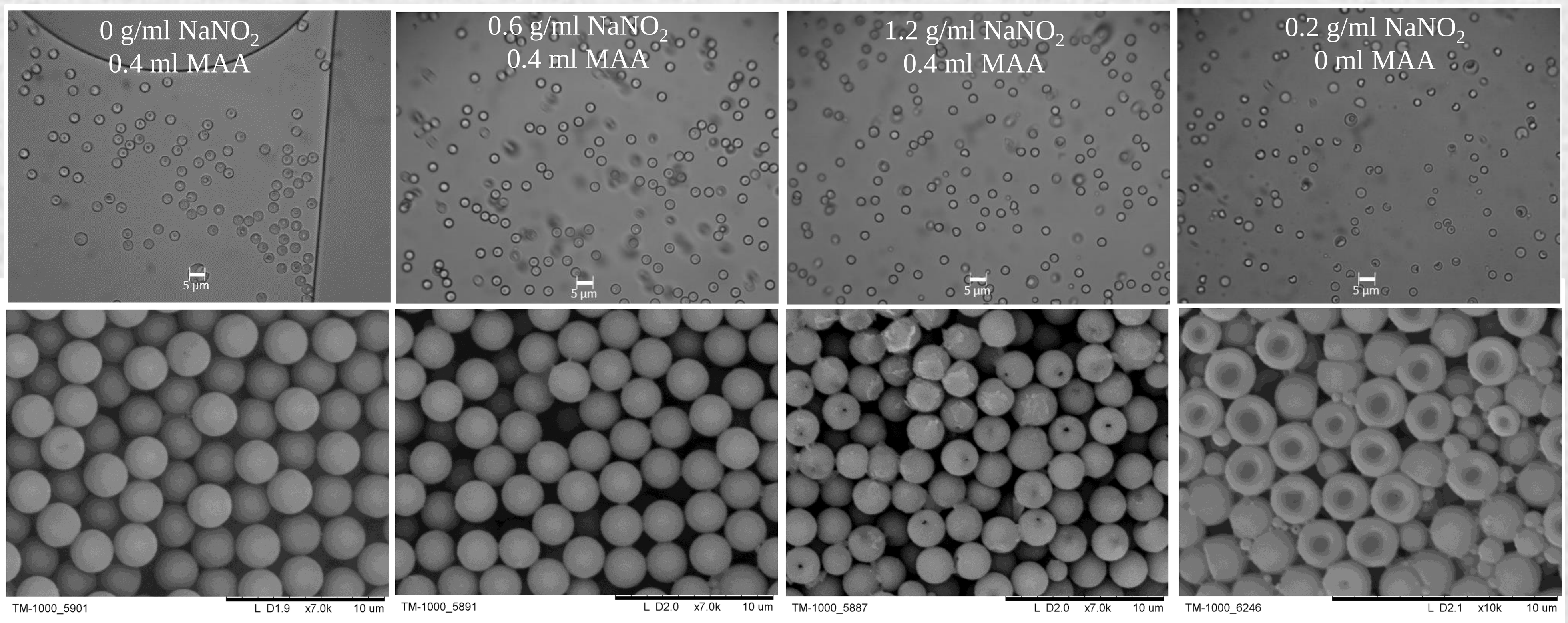
Effect of size of seed particles



Change in seed particle size influences the size of the resulting particles (larger seeds lead to larger particles), but neither shape nor morphology differ significantly.

Effect of inhibitor concentration

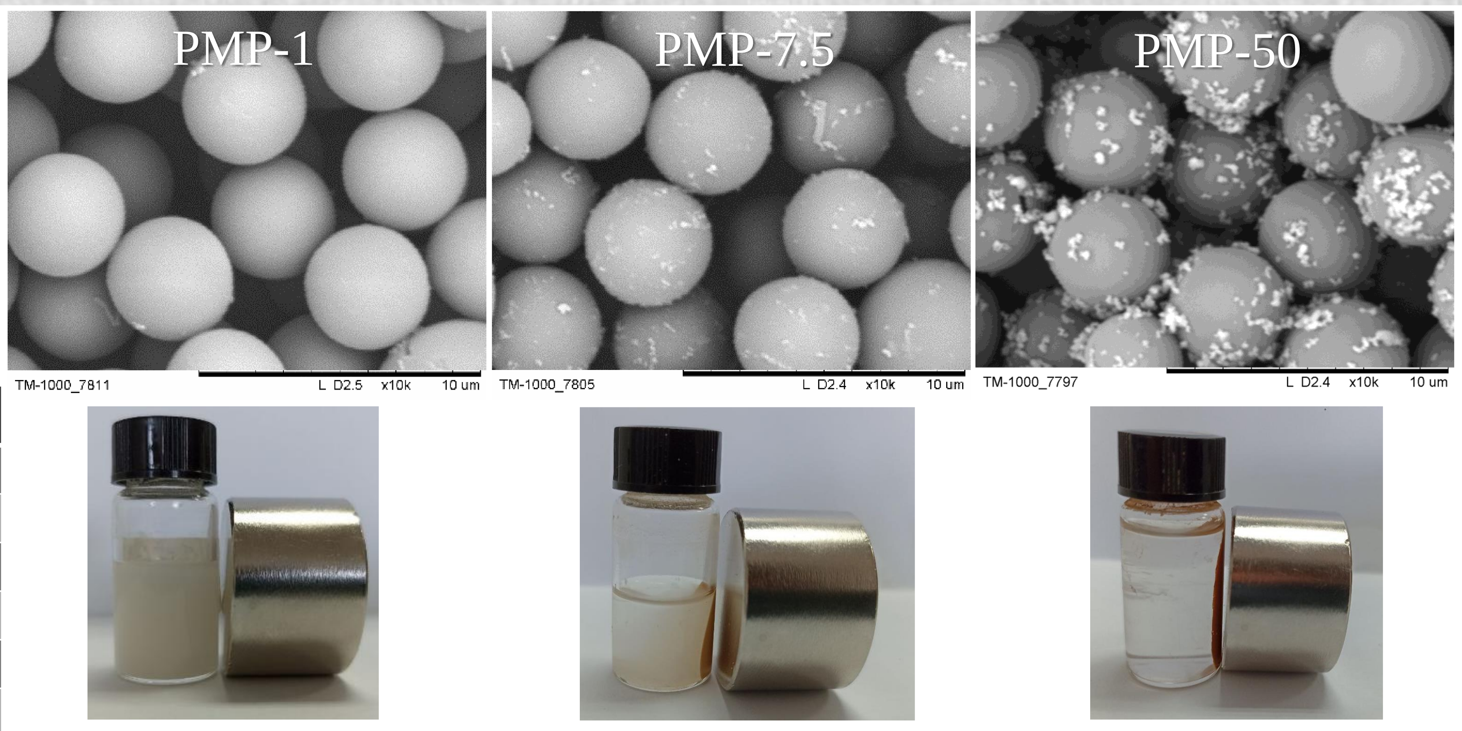




Increase in inhibitor concentration ($NaNO_2$) leads to no significant change in particle size. However, there is an increase in the concentration of carboxyl surface groups, indicating the incorporation of higher amounts of MAA. The increase in $NaNO_2$ concentration also influences the formation of defects within the polymer microspheres, which become more pronounced with higher inhibitor concentrations.

Swelling and penetration processes

Name	$m_{pol.p.}$, g	$m_{mag.p.}$, mg	V_{but}, ml	V_{tol}, ml
PMP-1	0.205	0.4	6	0.016
PMP-2,5	0.205	1	6	0.039
PMP-5	0.205	2	6	0.079
PMP-7,5	0.205	3	6	0.118
PMP-10	0.205	4	6	0.157
PMP-50	0.205	20	6	0.786



Increasing the amount of magnetic nanoparticles results in higher concentration of these particles on the polymer surface, as evidenced by both the intensification of particle coloring and improved magnetic properties. However, a higher quantity of magnetic nanoparticles also leads to the formation of larger aggregates. These aggregates can reach sizes to 1 µm in size and may desorb from the polymer surface within a matter of days. To prevent this, the possibility of implementing an additional coating can be considered. Composite particles in which no significant aggregates of magnetic nanoparticles are detected exhibit magnetic stability for a period of at least three months.

Conclusions

The diffusion technique was proposed for the synthesis of microsized uniform magnetic polymer microspheres possessing carboxyl groups. It was shown that:

1. Increasing the content of the swelling agent (DBP) from 1 ml to 4 ml per 1 g of seed particles, as well as using larger seed particles, results in larger polymer particles with a more uniform morphology.
2. To prevent the polymerization of the partially water-soluble monomer (MAA) in the aqueous medium, a water-soluble inhibitor ($NaNO_2$) can be utilized. However, increasing the inhibitor concentration although enhances the incorporation of MAA into the polymer particles, but also leads to the formation of defective polymer particles with noticeable dents.
3. The polymerization locus can be shifted to the surface of the seed particle by the use of a more water-soluble initiator (AIBN) producing polymer particles with core-shell structure.
4. The optimal content of magnetic nanoparticles (20 nm in size) lies in the region of 15-20 mg of magnetic nanoparticles per 1 g of polymer particles. Addition of insufficient quantities of magnetic nanoparticles results in magnetic-polymer particles with unsatisfying responsiveness to magnetic field. Conversely, excessive amounts of magnetic nanoparticles lead to formation of large (up to 1 µm) aggregates that easily desorb from the polymer particle surface.

Site of the template synthesis group of Boreskov Institute of Catalysis SB RAS https://www.gts-catalysis.ru

The work was conducted within the framework of the State assignment for Boreskov Institute of Catalysis SB RAS