MACROPOROUS POLYMERIC BEADS AS DELIVERY CONTAINERS FOR SELF HEALING AGENTS

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ABSTRACT

Wherever composites are exposed to mechanical stress, fatigue, impact etc., damage and cracks are likely to be produced. Propagating cracks can lead to an overall failure of the composite. To prevent cracks from growing and to restore the former properties the incorporation of self-healing abilities into a composite shall be explored. In our approach a self-healing agent shall be encapsulated and stored in macroporous polymers and its release triggered when a crack meets the capsule. A suitable container for the self-healing agent must be easily dispersible in the composite, be strong enough to withstand the incorporation process but weak enough to rupture when a crack occurs to release the self-healing agent. Macroporous beads have unique properties and can be modified to be either strong and rigid or soft and elastic. Due to this ability is it believed that they can not only bring self healing ability to composites but also work at the same time as functional additives that can improve the composites overall properties.

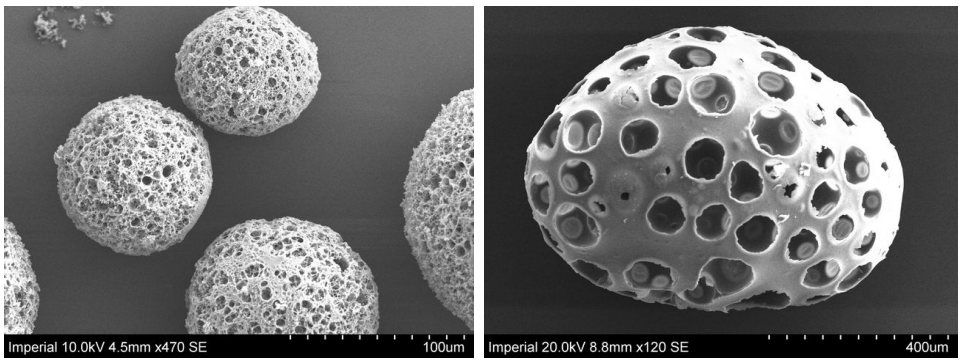

Figure 1: Macroporous beads with an interconnected (left) and an internal closed cell morphology (right) for their usage as self healing agent containers were produced.

We demonstrate the synthesis of macroporous polymer beads as possible containers for self-healing agents and their use as part of a composite structure. By using non-ionic surfactants and particles as stabilisers for the emulsion templates when producing these beads, we were able to produce macroporous beads with a high internal phase volume and different mechanical properties. We demonstrate the synthesis of porous beads with interconnected and closed cell morphology (see Figure 1) and present data on the suitability of these beads to act as effective capsules to deliver healing agents. Table 1 presents data of the average bead and pore sizes as well as on wall thickness and porosity of some in this approach produced macroporous beads via different polymerisation techniques.

Properties		1)	2)	3)	4)
Bead diameter	[μm]	775 ± 75	290 ± 35	515 ± 175	240 ± 10
Pore size	[μm]	95 ± 30	30 ± 10	3.3 ± 1.2	10 ± 4
Wall thickness	[μm]	2.4 ± 2.1	1.8 ± 0.9	0.3 ± 0.08	1.5 ± 1.0
Pore throat	[μm]	-	-	1.1 ± 0.4	2.0 ± 0.7
P	[%]	70 ± 1	n. m.	76 ± 2	n. m.
ρ_m	[g/cm^3]	1.460 ± 0.016	n. m.	1.0300 ± 0.003	n. m.
ρ_f	[g/cm^3]	0.440 ± 0.010	n. m.	0.290 ± 0.002	n. m.
Surface area	[g/m^2]	0.13 ± 0.02	n. m.	9.23 ± 0.04	n. m.

n. m. = not measured as not sufficient beads were produced for analytic device requirements

1) Suspension polymerisation Pickering beads
2) Microfluidic polymerisation Pickering beads
3) Suspension polymerisation non-ionic surfactant beads
4) Microfluidic polymerisation non-ionic surfactant beads

Table 1: Properties of produced macroporous beads via different polymerisation methods.

We were able to produce macroporous beads with diameters ranging from 240 to 775 μm with closed cell and interconnected porous morphologies using different polymerisation techniques. We were further able to in situ incorporate a reactive liquid and to release it upon compression demonstrating the ability of macroporous beads to act as a container for self healing agents. Further research will focus especially on reducing the bead size diameter and incorporating suitable self-healing agents.

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