Design of polymer colloids for use in functional biocoatings

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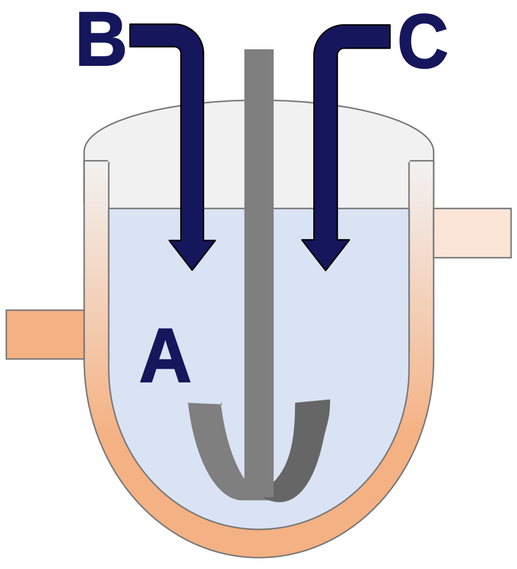
Porosity in colloidal biocoatings

In collaboration with Prof. Keddie and Prof. Hingley-Wilson, a bespoke colloidal dispersion was designed for use in functional biocoatings.[1] Outlined here is the design process and important latex characteristics that were targeted.

Considerations during design of particles

1. The surfactants must be non-toxic to embedded bacteria
2. Particles must be monodisperse for accurate investigation of the biocoatings' porosity
3. A glass transition temperature low enough for bacteria to tolerate during film formation but high enough to stop particle deformation at room temperature

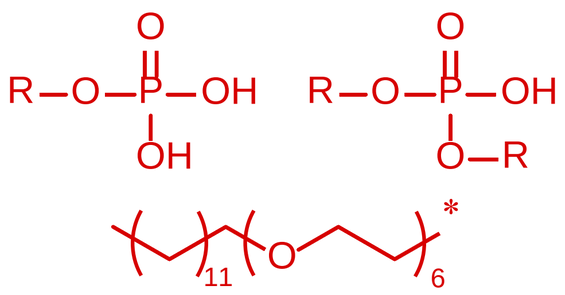
Particle synthesis by semi-batch emulsion polymerisation



A. Particle formation using 10 % (w/w) of total monomer in the reactor containing water, anionic surfactant and water soluble initiator
B. Following seed formation, 90 % (w/w) of total monomer added dropwise, slower than the maximum rate of polymerisation to ensure monomer-starved conditions
C. Non-ionic surfactant is added dropwise during the feed stage to stabilise the increasing particle surface area

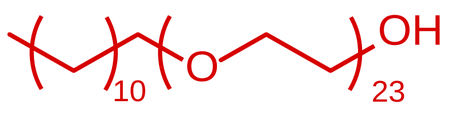
Non-toxic surfactant selection and usage

Anionic
Phosphate ester
Present from beginning



- Triggers **fast nucleation** producing monodisperse seed particles

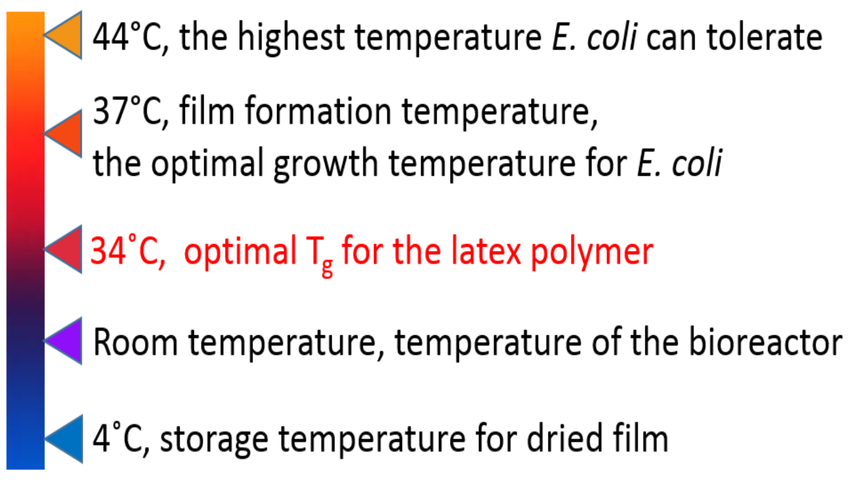
Non-ionic
Polyoxyethylene lauryl ether
Added during feed stage



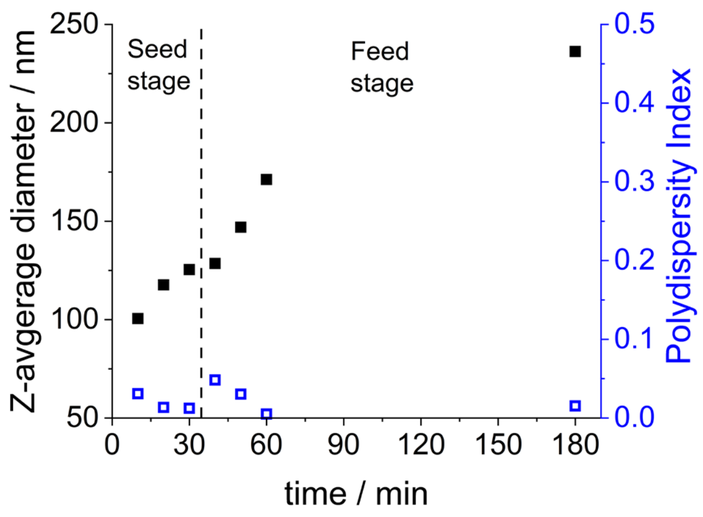
- Responsibly for **particle stability** at high particle volume fractions
- **Avoids secondary nucleation** in feed stage as less effective for particle formation

Optimum glass transition temperature

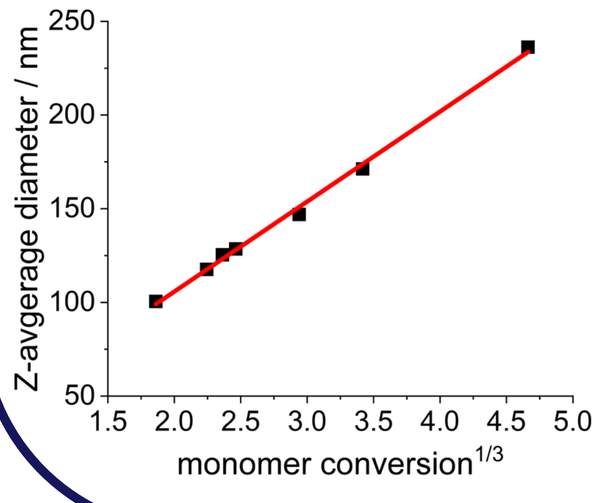
A single T_g of 34 °C was achieved using monomer-starved conditions to synthesise a statistical copolymer

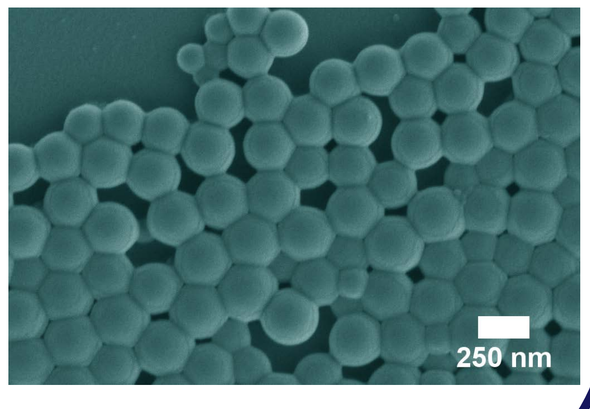


Control of particle size and size dispersity



- Anionic phosphate ester surfactant stabilised the particles during the seed stage to produce 125 nm diameter particles
- Non-ionic surfactant was added during the feed stage to prevent particle coalescence without triggering secondary nucleation. This is confirmed by the linear relationship between Z-average diameter and the cube root of monomer conversion





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References
1) Y. Chen, S. Krings, J. R. Booth, S. A. F. Bon, S. Hingley-Wilson and J. L. Keddie, Biomacromolecules, DOI:10.1021/acs.biomac.0c00649