Soft self-assembled nanoparticles with temperature-dependent properties

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Valence-limited building blocks

- Soft matter materials can be engineered to a high degree
Valence-limited building blocks

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- Colloids can be seen as “large atoms”...

Colloids as Big Atoms
Wilson Poon
*Science* 304, 830 (2004);
DOI: 10.1126/science.1097964
Valence-limited building blocks

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Valence-limited building blocks

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- Colloids can be seen as “large atoms”... or molecules!
- Limited valence → open structures
A hierarchical self-assembly

- *Hard “patchy” colloids are difficult to synthesise*

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- A different approach: self-assembling (bio)polymers
A hierarchical self-assembly

- Hard “patchy” colloids are difficult to synthesise
- A different approach: self-assembling (bio)polymers
- New challenges (and opportunities): intrinsic softness

3LR et al., ACS Nano (2014)
Telechelic star polymers

The recipe

1. Take $f$ diblock co-polymers (attractive-to-repulsive ratio $\alpha$)
Telechelic star polymers

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**Telechelic star polymers**

**The recipe**

1. Take \( f \) diblock co-polymers (attractive-to-repulsive ratio \( \alpha \))
2. Graft them on a central anchoring point (\( R \ll R_g \))

- Experimentally viable (e.g. with zwitterionic end groups)
- Simulations show formation of ordered and disordered phases

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The role of the temperature

- $T$ controls the attraction between end monomers

Cooling process
The role of the temperature

- $T$ controls the attraction between end monomers
- At low $T$ “patches” form
The role of the temperature

- $T$ controls the attraction between end monomers
- At low $T$ “patches” form
- Patch number and size depend on $f$, $\alpha$ and $T$

![Graph showing the number of patches versus $\lambda$ for $\alpha = 0.3$ and $\alpha = 0.7$](image-url)
Tuning the flexibility

- TSP’s are inherently floppy

Angular flexibility

Radial flexibility
Tuning the flexibility

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- $f$, $\alpha$ and $T$ control flexibility
Tuning the flexibility

- TSP’s are inherently floppy
- $f$, $\alpha$ and $T$ control flexibility
- Same patch geometry, different flexibility $\rightarrow$ materials with similar structures, different mechanics
In the bulk
In the bulk

![Graph showing the number of patches against cooling parameter \( \lambda \). The graph compares the single star (orange circles) and bulk (blue squares) scenarios.](image)
Outlook and conclusions

- TSP’s self-assemble into soft patchy particles\(^1\)

\(^1\)LR et al., Nanoscale (2015)
Outlook and conclusions

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- Their self-assembly can be finely controlled

\(^1\)LR et al., *Nanoscale* (2015)
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Thanks for your attention!