The exchange dynamics of supramolecular building blocks at the interface

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Introduction

Synthetic self-assembling supramolecular hydrogelators can recapitulate the key properties of a dynamic extracellular matrix in a biomimetic fashion.

Building blocks consisting of a linear poly(ethylene glycol) (PEG) backbone terminated with alkyl spacers and ureidopyrimidinone (UPy) units assemble into supramolecular fibres via hydrogen bonding, π-π-stacking, and hydrophobic interactions. Monofunctional building blocks (mUPy) yield stable fibres; bifunctional versions (bUPy) are highly dynamic and can also crosslink the fibres above a certain concentration. Co-mixing of mUPy and bUPy has a synergistic effect: solutions (non-gel-forming regimes) of both materials can form hydrogels together.

In this study, a novel approach to investigate the evolution of the system and exchange dynamics of the building blocks at the interface between solutions of mUPy and bUPy is introduced.

Experimental Design

Solutions of mUPy (MF) and bUPy (BF) are prepared at varying concentrations (<1 wt% for bUPy to avoid crosslinking) with addition of small amounts of fluorescently-labelled mUPy (mUPy-dye): mUPy-Cy5 (blue) for MF, mUPy-Cy3 (green) for BF. Alternatively, mUPy-Fluorescein (green) and Nile Red (red) are used. Labelled MF and BF solutions are brought into contact at an interface within a confined channel and studied at the confocal microscope over time. Signal intensities are plotted as a function of distance from the interface at different times.

Results

MF and BF solutions in the channel form a clear interface and do not mix. Over time, the mUPy-dye from BF can be seen to diffuse into the MF region, while the opposite is not observed. This is attributed to presence of free mUPy-dye molecules in BF due to the high dynamicity of bUPy stacks. The rate and extent of diffusion appears higher for more dilute BF solution (higher mUPy/bUPy ratio).

Outlook & Future Work

The novel channel slide set-up here introduced is a versatile and effective tool to study the interactions and exchange dynamics of supramolecular building blocks at an interface between two solutions. The different exchange dynamics of mUPy and bUPy govern the interdiffusion and crosslinking behaviour at the border and allow to tailor the system properties to the desired application.

Future work would aim to increase the resolution through more specific imaging techniques (FRET, TIRF, STED) and better quantify the diffusion and dynamics. The interface would be investigated via electron microscopy (SEM) to assess the assembly and potential crosslinking.

A 3D set-up will be developed to assess the feasibility and potential of printing structures with spatially varying properties by combining mUPy and bUPy. An intended application for this technique would be to create locally tailored environments for cells as more sophisticated dynamic matrices for tissue engineering.

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