Formation of metal-bioorganic nanofibres on a microchip

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The past decade has evidenced an explosive growth in research aimed to control and guide the assembly of different molecular building blocks. Among others, normal synthetic procedures are focused in lithographic, vapour deposition and electron-beam based technologies.¹ These processes involve complex, expensive and time consuming techniques. Owing to this fact, much effort has been conducted to find alternative methods. In this sense, microfluidics has emerged as an advanced alternative approach for controlling and guiding large molecular assemblies.²,³

Here we report the microfluidics-guided assembly of a coordination polymer based on copper ions and sodium aspartate (Cu(II)-Asp). This microfluidic approach demonstrates the formation of nanofibres within milliseconds at the interface of the two reactant streams (Fig. 1).

In a typical synthetic procedure two aqueous solutions containing Cu(NO₃)₂·3H₂O (1.5 mM) and L-aspartic acid (1 mM) and NaOH (2.5 mM), respectively, were injected via a syringe pump system into a four-channel microfluidic platform. The reactants were applied in the central channels, (Fig. 1, channels (b) and (c)) and guiding of the assembly through the entire chip was accomplished by modifying two aqueous auxiliary streams. (Fig. 1, channels (a) and (d))

We investigated the formation under various conditions, including changes of the volume flow rates of the reagent and auxiliary side streams. Studies of the eluted structures by scanning electron microscopy corroborated the nanowire morphology described previously in bulk.⁴ However, while in bulk synthesis the reaction time last from few hours to a days, it is reduced to milliseconds in the microfluidic reactor. Moreover, the ease to adjust flow rates on this system leads to control over the reaction zone of the two reactants. Consequently, guiding and positioning of the structures can be addressed just by changing sheath flow or reactants flow rates (Fig. 2).

In summary we have presented a new route for a straightforward production of metal-organic frameworks by using microfluidic technologies. We anticipate that this is a general approach enabling fast and well-controlled nanowire formation of other metal organic/bioorganic composite materials and possesses the ability of guiding and tuning the formation pathway of the assembled structures just by varying flow-rate conditions.

REFERENCES:

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