Graphene-Enabled Templating Synthesis of Metal Origami for Next-Generation Soft Robotics

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Soft robotics seek to replicate the soft-bodied structures found in animals, allowing for a diverse range of movements. Conventional soft-materials exhibit limited functionality, serving support or actuating purposes only, while noble metals confer multifunctional properties, including biocompatibility, thermal stability and electrical conductivity. These are necessary for actuation in prosthetics or targeted drug delivery, where robots navigate through vasculatures with remote magnetic guidance delivering drugs to a specific target organ. Thus, we seek to develop a free-standing noble metal structure capable of magnetic actuation. The synthesis utilised cellulose origami structures as precursors in the paper-templating method followed by a novel two-stage calcination technique, composed of burning in Ar followed by air. Additional soaking with graphene oxide achieved increased loading of metal ions, improving its final structural integrity. Optimal synthesis conditions such as the ideal noble metal (Pt), calcination temperature and duration were also determined. Next, the film was functionalised with a PDMS-NdFeB coating. A decrease in Young’s modulus in tensile strength tests and increase in magnetic hysteresis showed that the coating confers greater flexibility, higher fracture resistance and permanent magnetic memory to the structure. This allows various modes of transformations between 3D shapes via magnetic actuation. This is further complemented by the conductivity of the metallised structure via selective application of the PDMS coating. Thus, a durable, flexible, free-standing multifunctional structure has been successfully synthesised, capable of being remotely controlled in magnetic fields with potential applications in prosthetics and targeted drug delivery.