Scalable and integrated flow synthesis of triple-responsive nano-motors via microfluidic Pickering emulsification

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This paper presents development and evaluation of continuous-flow synthesis of tripley-responsive (thermophoretic, chemical and magnetic movement) nano-motors ($mSiO_2/Fe_3O_4$-Pdop/Pt) by microfluidic Pickering emulsification in an integrated and scalable process. The droplet microfluidic process allows efficient self-assembly of the silica nanoparticles surrounding the spherical interface of resin droplet, rendering excellent Pickering efficiency and reproducibility, and is followed by anisotropic decoration of Pdop (polydopamine) and Pt (platinum) catalyst in a serial flow process. The obtained Janus nanoparticles reveals doubly- or triply-responsive self-propulsions with synergic mobility by combining thermophoresis powered by light, catalytic driven motion in H_2O_2 (hydrogen peroxide) or magnetic movement by magnet. The nanoparticles achieved the first themophoretic motion by Polydopamine. This novel integrated flow strategy proves a scalable manufacturing production (> 0.7 g hr^{-1}) of the nano-motors using inexpensive single microreactor, and thereby fulfils quantitative and qualitative needs for versatile applications.