Porphyrrins are aromatic, organic, light-absorbing molecules that occur abundantly in nature, especially in the form of molecular self-assemblies. In 2011, we first discovered ‘porphysomes’, the self-assembled porphyrin-lipid nanoparticles with intrinsic multimodal photonic properties. The high-density porphyrin packing in bilayers enables the absorption and conversion of light energy to heat with extremely high efficiency, making them ideal candidates for photothermal therapy and photoacoustic imaging. Upon nanostructure dissociation, fluorescence and photodynamic activity of porphyrin monomers are restored. In addition, metal ions can be directly incorporated into the porphyrin building blocks of the preformed porphysomes thus unlocking their potential for positron emission tomography and magnetic resonance imaging. By changing the way porphyrin-lipid assembles, we developed lipoprotein-mimicking porphyrin nanoparticles, porphyrin microbubbles, giant porphyrin vesicle, hybrid porphyrin-metal nanoparticles and metal chelating texaphyrin nanoparticles. By mimicking the light harvesting systems found in photosynthetic bacteria, we have created supramolecular assemblies of highly ordered porphyrin aggregates possessing stimuli-responsive photonic properties. Such optical properties are also responsible for our discovery of the ultrasound-induced microbubbles-to-nanoparticle conversion phenomenon. In summary, the simple yet intrinsic multimodal nature of porphyrin nanoparticles represents a new nanomedicine paradigm and also confers its high clinical translation potential.

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