Crystalline 'artificial muscle' makes paper doll do sit-ups

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Foil paper doll, as seen above, is able to move thanks to a new material. Credit: American Chemical Society

Scary movies about dolls that can move, like Anabelle and Chucky, are popular at theaters this summer. Meanwhile, a much less menacing animated doll has chemists talking. Researchers have given a foil "paper doll" the ability to move and do sit-ups with a new material called polymer covalent organic frameworks (polyCOFs). They report their

results in *ACS Central Science*.

Scientists make conventional COFs by linking simple organic building blocks, such as carbon-containing molecules with boric acid or aldehyde groups, with covalent bonds. The ordered, porous structures show great potential for various applications, including catalysis, gas storage and drug delivery. However, COFs typically exist as nano- or micro-sized crystalline powders that are brittle and can't be made into larger sheets or membranes that would be useful for many practical applications. Yao Chen, Shengqian Ma, Zhenjie Zhang and colleagues wondered if they could improve COFs' mechanical properties by using linear polymers as building blocks.

The researchers based their polyCOF on an existing COF structure, but during the compound's synthesis, they added polyethylene glycol (PEG) to the reactants. The PEG chains bridged the pore space of the COF, making a more compact, cohesive and stable structure. In contrast to the original COF, the polyCOF could be incorporated into flexible membranes that were repeatedly bent, twisted or stretched without damage. To demonstrate how polyCOFs could be used as an artificial muscle, the team made a doll containing the membrane as the waist and aluminum foil as its other parts. Upon exposure to ethanol vapors, the doll sat up; when the vapors were withdrawn, it laid down. The researchers repeated these actions several times, making the doll do "sit-ups." The expansion of polyCOF pores upon binding the gas likely explains the doll's calisthenics, the researchers say.

More information: Zhifang Wang et al, PolyCOFs: A New Class of Freestanding Responsive Covalent Organic Framework Membranes with High Mechanical Performance, *ACS Central Science* (2019). DOI: 10.1021/acscentsci.9b00212

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