基于多重氢键构筑可再生纤维素/液态金属复合弹性体

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摘　要:【目的】利用生物质资源制备一种可持续的具有优异机械性能、可回收性以及光热转换能力的液态金属复合弹性体。【方法】将液态金属掺杂到含有氨基纤维素（AC）、羧基化环氧大豆油（ESOPA）以及天然橡胶（NR）的弹性体基质中设计一种氢键交联的生物基液态金属复合弹性体，通过拉伸试验、模拟日光照射等实验方法测试液态金属复合弹性体的机械性能、可回收性及光热转换能力。【结果】1）氨基纤维素、羧基化环氧大豆油及天然橡胶组成的弹性体基质中丰富的羟基、氨基和羧基等活性基团有助于液态金属在弹性体基质中稳定的分散以及形成稳定的多重氢键网络；2）多重氢键网络赋予复合弹性体优异的机械性能，拉伸强度和断裂伸长率分别可以达到 1.51 MPa 和 515.3%；3）可逆多重氢键网络的存在使复合弹性体具有优异的自修复能力，自修复 3h 后断裂伸长率的修复效率达到 97.28%；4）多重氢键网络还赋予复合弹性体良好的可回收和可再生能力，并且在回收过程能够分离提取液态金属，液态金属的回收效率可达 85%；5）液态金属的存在赋予复合弹性体优异的光热转换能力，并且成功应用于斯特林发动机及电动马达等领域，实现了清洁能源的收集与转换。【结论】丰富的活性基团有利于液态金属的稳定分散以及构筑多重氢键网络；利用由纤维素、油脂、天然橡胶等生物质资源组成的多重氢键网络制备的可持续的液态金属复合弹性体具有优异的机械性能、可回收性及光热转换能力。

关键词：纤维素；液态金属；复合弹性体；光热转换；多重氢键网络

Multiple hydrogen bonds enabled reproducible cellulose/liquid metal composite elastomer

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Abstract:【Objective】Fabrication of sustainable, mechanically robustness and reproducible metal polymer composite elastomer is desirable but remains a challenge. Herein, a multiple hydrogen bonds crosslinked metal polymer composite elastomer derived from cellulose, plant oil, nature rubber and liquid metal was prepared, which exhibited excellent mechanical elasticity, reproducible and photothermal conversion performance. 【Method】In this study, the proposed composite elastomer was fabricated by dispersing the liquid metal (LM) droplets within a mixture of amino cellulose (AC), pimelic acid modified epoxy soybean oil (ESOPA) and nature rubber matrix through high-frequency ultrasonication. And the mechanical properties, recyclability and photothermal conversion performance of liquid metal composite elastomer were analyzed by tensile tests and simulated sunlight irradiation. 【Result】1) To fabricate the proposed composite elastomer, the liquid metal (LM) droplets were dispersed within a mixture of amino cellulose (AC), pimelic acid modified epoxy soybean oil (ESOPA) and nature rubber matrix through high-frequency ultrasonication. The active groups of the AC and ESOPA were able to not only construct a multiple hydrogen bonds network, but also stabilize the LM particles. 2) The multiple hydrogen bonds network endows the composite elastomer with excellent mechanical strength (1.51 MPa) and stretchability (515.3%). 3) With the broken and reconstruction of the multiple hydrogen bonds network, the composite elastomer could be healed quickly at room temperature with high self-healing efficiency of 97.28% after healing 3 h. 4) The multiple hydrogen bonds crosslinked composite elastomer has weaker bond energy and better solubility in organic solvents than covalent crosslinked composites, which provided great convenience for the reproduction of the LM-based

composite elastomer and the recycling of LM in the waste composite elastomers, and the recycling efficiency of LM was up to 85%. 5) Most importantly, the NR/ESOPA/AC/LM composite elastomer possessed stable photothermal conversion property, and has been successfully applied to convert light energy to thermal, electric and kinetic energy to drive the Stirling motor and electric fan, which paved a promising strategy for clean energy collection and conversion. 【Conclusion】The abundant active groups were able to stabilize the LM and construct a multiple hydrogen bonds network. The multiple hydrogen bonds crosslinked bio-based composites elastomer derived from AC, ESOPA and NR exhibited excellent mechanical properties, reproducible ability, and photothermal conversion performance.

Key words: cellulose; liquid metal; composite elastomer; photothermal conversion; multiple hydrogen bonds network.