**Repairable, Recyclable, and Stretchable Electronic Materials**

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Materials capable of regenerating after damage have attracted considerable interest since ancient times. For example, self-healing concretes resistant to earthquakes, aging, weathering, and seawater were used in ancient Rome and continue to be the subject of modern research.

While a variety of mechanically self-healing materials have been developed, self-healing conductors remain relatively scarce. Nevertheless, they are garnering significant attention for applications in electronic skin, wearable and stretchable sensors, actuators, transistors, energy harvesting systems, and energy storage devices such as batteries and supercapacitors.¹ These self-healing and recyclable conductive materials offer the potential to reduce electronic waste by enabling the repair and reuse of damaged components, thereby extending the lifespan of electronic devices. They are particularly relevant for wearable and biomedical electronics, which are frequently exposed to mechanical stress that can damage their components.

Conducting polymers possess several properties that make them well-suited for bioelectronics and stretchable electronics, including mixed ionic-electronic conductivity (resulting in low interfacial impedance), chemical tunability, solution processability (including compatibility with printing techniques), and biomechanical compatibility with living tissues. However, their generally poor mechanical robustness limits their intrinsic self-healing capabilities.

To address this challenge, our group has developed a series of self-healing and stretchable conductors by blending aqueous suspensions of the conducting polymer poly(3,4-ethylenedioxythiophene):polystyrene sulfonate (PEDOT:PSS) with mechanically reinforcing materials such as polyvinyl alcohol (PVA), polyethylene glycol (PEG), polyurethanes, and tannic acid.2-9

In this presentation, I will highlight different types of self-healing behaviors and relate them to the corresponding electrical and mechanical properties of the materials. Applications of these self-healing gels and films as epidermal electrodes, electronic tattoos, and other flexible devices will also be discussed.

1. Y. Li, X. Zhou, B. Sarkar, F. Cicoira et al., *Adv. Mater.* 2108932, 2022.
2. Y. Li, X. Li, S. Zhang, F. Cicoira et al., *Adv. Funct. Mater.* 30, 2002853, 2020.
3. Y. Li, X. Li, R. N., S. Zhang, F. Cicoira, et al. *Flexible and Printed Electronics* 4, 044004, 2019.
4. S. Zhang, Y. Li, F. Cicoira et al. Adv. Electron. Mater1900191, 2019.
5. S. Zhang, F. Cicoira, Adv. Mater. 29, 1703098, 2017.
6. X. Zhou, G. A. Lodygensky, F. Cicoira et al., *Acta Biomaterialia* 139, 296-306, 2022.
7. P. Kateb et al., *Flexible and Printed Electronics*, 8 (4), 045006, 2024.
8. X. Zhou, F. Cicoira et al., J. Mater. Chem. C, 12, 5708, 2024.
9. J. Kim., F. Cicoira et al. Mater. Horiz. 11, 348, 2024.