in transporting charges is relevant, from OLEDs to solar cells, transistors, sensors and thermoelectrics.

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References
1. Fratini, S., Nikolka, M., Salleo, A., Schweicher, G. & Sirringhaus, H. *Nat. Mater.* **19**, 491–502 (2020).
2. Brédas, J.-L., Beljonne, D., Coropceanu, V. & Cornil, J. *Chem. Rev.* **104**, 4971–5003 (2004).
3. Fratini, S., Ciuchi, S., Mayou, D., Trambly de Laissardière, G. & Troisi, A. *Nat. Mater.* **16**, 998–1002 (2017).
4. Haneef, H. F., Zeidell, A. M. & Jurchescu, O. D. *J. Mater. Chem. C* **8**, 759–787 (2020).
5. He, T. et al. *Nat. Mater.* https://doi.org/10.1038/s41563-021-01079-z (2021).
6. Lüssem, B. et al. *Chem. Rev.* **116**, 13714–13751 (2016).
7. Giovannitti, A. et al. *Proc. Natl Acad. Sci. USA* **113**, 12017–12022 (2016).

Competing interests
The author declares no competing interests.

BIOADHESIVES

A photocurable bioelectronics–tissue interface

A functional bioadhesive has been developed to possess properties such as mechanical compliance, electrical conductivity and optical transparency, and is utilized for bonding electronic devices to various organs in the body for up to several months.

Tsuyoshi Sekitani

A number of implantable devices have been developed for use within the human body for both the diagnosis and treatment of various complications[1–3]. Several techniques have been utilized to attach such devices to organs and tissues in the body, such as suturing and stapling. However, many of these approaches damage the surrounding tissue over time and generally do not offer long-term stability of the implanted devices. As a more desirable alternative, adhesives have been widely used[4–7]. However, for adhesives to be effective, they must be mechanically compliant with the surrounding tissue, be applicable for a diverse range of bioelectronic systems, be biocompatible with tissues and cells, support the dynamic motion of organs such as the heart, and function in the wet environment of organs.

Now, writing in *Nature Materials*, Quansan Yang and colleagues[8] report the development of a functional biointerfacial adhesive for bonding electronic devices to organs in the body (Fig. 1). The adhesive, termed bioelectronics–tissue interface material (BTIM), was designed to be resorbable, permit light transmission and be ionically conductive. The adhesive is composed of polyethylene glycol–lactide acid diacrylate and sodium alginate; the precursors are highly viscous and can flow to conform with and cover the surface of various tissues and organs. The adhesive is then photocured by exposure to ultraviolet light for 3 minutes, inducing a liquid-to-solid transformation.

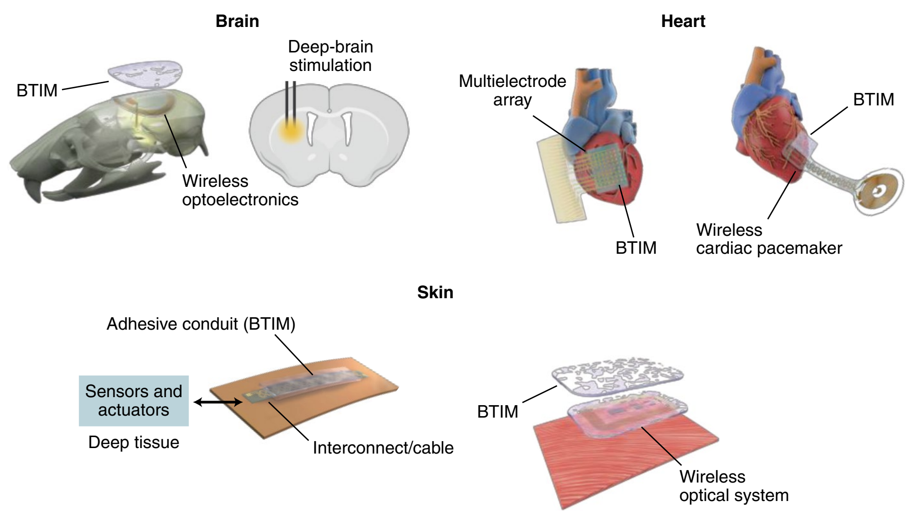

Fig. 1 | Applications of BTIM. The bioadhesive material is designed to be resorbable and mechanically compliant and offers the potential to integrate electronic/optoelectronic devices with organs and tissues within the body, such as the brain, skin and heart. Figure adapted with permission from ref. 8, Springer Nature Ltd.

The strength of adhesion to various organs, such as the skin, epicardium and hepatic lobules, and various materials, such as polyurethane, polycaprolactone and polylactic acid, was analysed. The results indicate that BTIM is indeed effective for wet adhesion. BTIM was also designed to be resorbable through hydrolysis and enzymatic reactions, with the degradation rate being tunable by varying the lactide concentration. The conductivity of BTIM was found to be similar to that of most biofluids, and when tested with a cardiac pacemaker and a flexible microelectrode array it was shown that the adhesive could provide optimal conductivity without substantial signal degradation. Also, the optical transmittance was tested and found to be between 60% and 80% for wavelengths of light between 395 nm and 475 nm and remained higher than 80% between 475 nm and 900 nm.

Yang and colleagues investigated the potential of BTIM as an adhesive for several devices. One such device was a wireless light delivery system for phototherapy. It consisted of an inorganic light-emitting diode and an inductive antenna. It was placed on a subcutaneous region in a mouse model and secured with the BTIM adhesive, and it remained intact and functional for up to 2 months in vivo. The authors also investigated in a mouse model the potential of using BTIM for bonding an optogenetic device onto the skull and enabling deep-tissue stimulation in the brain via adhesion to the cerebrum. There was evidence that BTIM was biocompatible with the brain tissue as shown by the activation of astrocytes and microglia. In addition, BTIM was used with a bioresorbable optical filter, which can block excitation light but allow the transmission of light of a desired wavelength. When used with the cardiac pacemaker as described earlier, BTIM was found to lead to minimal scar tissue formation compared with the use of sutures in a rat model. Daily pacing studies demonstrated that scar tissue from sutures led to the failure of the pacemaker, whereas the pacemaker bonded with the BTIM adhesive was capable of pacing for up to 8 days post-surgery. Furthermore, the authors studied the application of the BTIM adhesive for the firm attachment of flexible multielectrode arrays to the epicardium and showed that there was negligible signal block or short circuit.

Even in the field of advanced materials, the foreign body reaction leading to the rejection of implanted devices is still a major problem and hinders the functionality and efficacy of these devices. With the advent of new biocompatible materials, such as BTIM, the use of devices that are designed to target tissues and cells deep within the brain and other organs thus becomes more likely.

In their study, Yang and colleagues have opened the door for the development of interfacial technologies with superior bioadhesive properties that can enable human–machine interfaces and that have the potential to enable new medical treatments not previously possible. ❐

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References
1. Feiner, R. et al. *Nat. Mater.* **15**, 679–685 (2016).
2. Jun, J. J. et al. *Nature* **551**, 232–236 (2017).
3. Mickle, A. D. et al. *Nature* **565**, 361–365 (2019).
4. Feiner, R. & Dvir, T. *Nat. Rev. Mater.* **3**, 17076 (2018).
5. Yuk, H. et al. *Nature* **575**, 169–174 (2019).
6. Li, J. et al. *Science* **357**, 378–381 (2017).
7. Lin, X. et al. *Nat. Biomed. Eng.* **3**, 632–643 (2019).
8. Yang, Q. et al. *Nat. Mater.* https://doi.org/10.1038/s41563-021-01051-x (2021).

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