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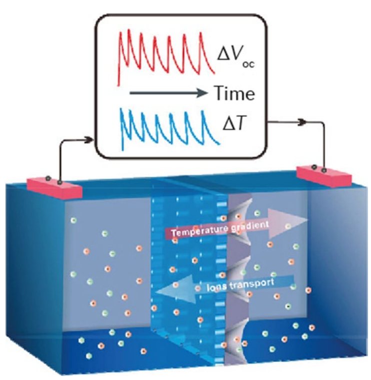
NANOCHANNELS

A bionic thermometer

> This thermosensitive system mimics ion channel-based biosensation processes and has promise for probing the temperature changes in photothermal processes and for thermo-energy conversion

Nature has evolved a highly sophisticated signalling system that informs our brain of changes in the surrounding environment. Usually, changes in pH, concentration or temperature are quickly transformed into electric signals that lead to an action. These processes are ultrafast and reproducible and prevent us from, for example, suffering terrible burns. Writing in the *Journal of the American Chemical Society*, a group led by Bin Su have reported a bioinspired thermoresponsive device made of solid-state nanochannels that induce thermally selective ion transport.

All organisms have developed a vital sensory process, known as thermosensation, which enables a prompt reaction in response to temperature changes. This is possible because of the presence of transient receptor potential (TRP) channels in the cell membrane of most animals. These are temperature-sensitive ion channels that respond to temperature changes by generating an ion concentration gradient that ultimately results in an electrochemical potential difference, and is translated into an action potential by the nerve endings. "Inspired by nature, scientists have designed bionic nanochannels by grafting temperature-responsive molecular brushes onto the walls or at the entrances of channels as gatekeepers for ion transport. However, in these models the response to temperature change is not continuous and is observed as a change in current flow instead of a potential difference," says Su. "To the best of our knowledge, the thermosensation arising from the intrinsic structure of solid-state nanochannels has not been observed yet in the form of potential."



Credit: Chen, K. et al. (2019), ACS.

The preferential passage of certain ions through a membrane is known as permselectivity, and is the key parameter that defines thermosensitivity. Furthermore, channel asymmetry can have important implications for the overall thermosensitivity. Su and co-workers had previously found that silica nanochannel membranes exhibit an excellent cationic permselectivity. A silica nanochannel membrane was therefore further investigated in this study, in this case it was supported by a large track-etched poly(ethylene terephthalate) conical nanochannel membrane. This engineered asymmetric membrane was used to separate two aqueous electrolytes both in the presence and absence of a concentration gradient. In both cases, the temperature on one side of the membrane was changed and Su and co-workers were able to measure a response to the thermal stimulus of 0.71 mV K^{-1}, comparable to the thermosensation observed in biosystems.

The presence of a cationic permselective membrane and a temperature difference between the two electrolytes leads to the formation of both temperature and concentration gradients, the latter predominating at the boundary of the nanochannels.

The thermal stimulus and the concentration gradient drive ion transport in opposite directions. The result is a permselective ion transport through the nanochannel that results in a potential difference that can be recorded under the open-circuit conditions as a temperature change.

"This thermosensitive system mimics ion channel-based biosensation processes and has promise for probing the temperature changes in photothermal processes and for thermo-energy conversion. We hope that it can be further developed to function as an analytical tool enabling the quantitative measurement of local ion transport," concludes Su.

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ORIGINAL ARTICLE Chen, K., Yao, L. & Su, B. Bionic thermoelectric response with nanochannels. *J. Am. Chem. Soc.* https://doi.org/10.1021/jacs.9b03569 (2019)