Thermosensitive crystallization-boosted liquid thermocells for low-grade harvesting

Boyang Yu et al., Jun Zhou*, Zhonglin Wang*

Wuhan National Laboratory for Optoelectronics, Huazhong University of Science and Technology.

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Science

Outline

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2. Thermopower (S_e) enhancement
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Liquid-state thermocells (LTC)

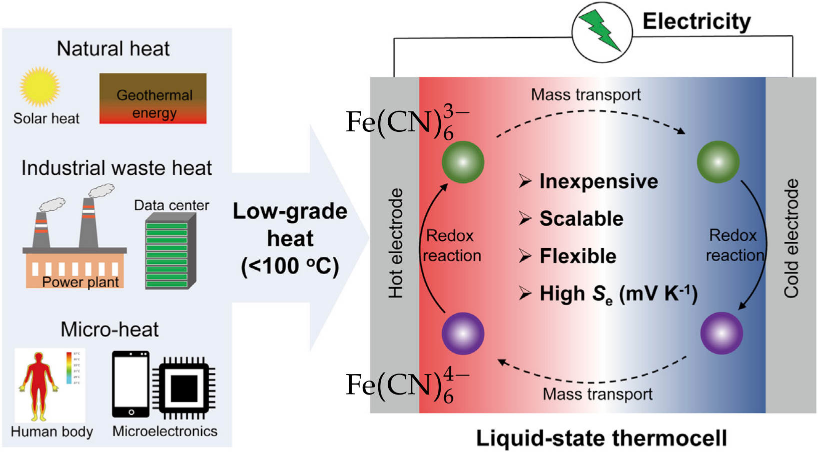

Figure 1: heat-electricity conversion via the liquid-state thermocell.

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Ways to enhance conversion efficiency in thermocells

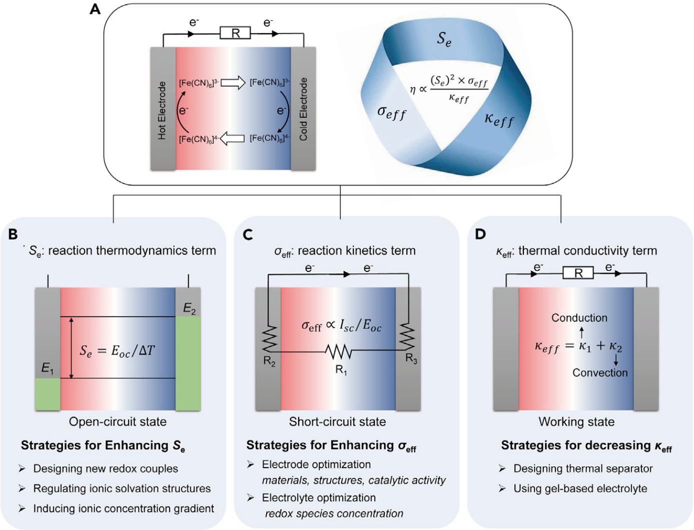

Figure 2: Three main directions.

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Thermopower (S_e) enhancement

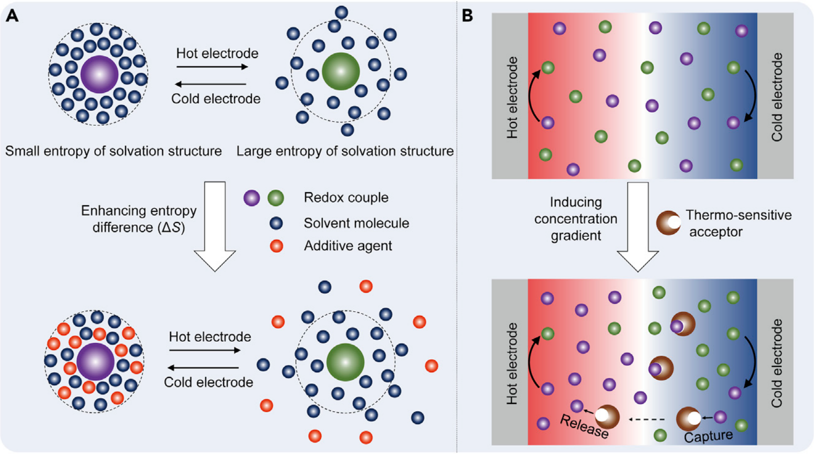

Figure 3: (A) Enhancing entropy difference of solvation structures between redox couples by introducing specific additive agents. (B) Inducing redox species concentration gradients by introducing thermosensitive acceptors.

Crystallization-inducing enhancement of S_e

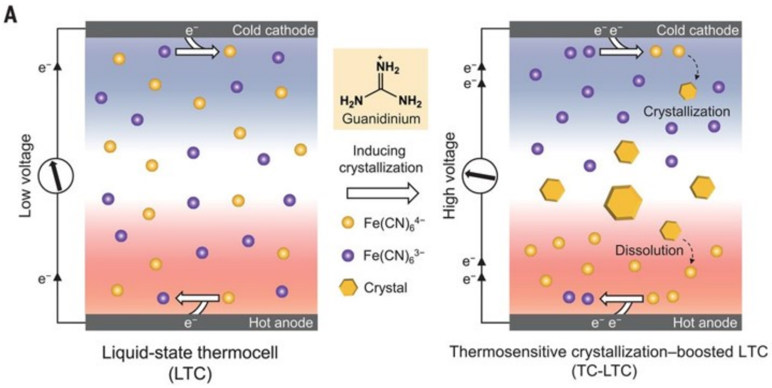

Figure 4: Schematic of guanidinium cations (Gdm^+) inducing $\mathrm{Fe(CN)}_6^{4-}$ crystallization and enhancement of the Seebeck effect in the 0.4 M $\mathrm{K_3Fe(CN)_6/K_4Fe(CN)_6}$

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Comparisons between different additives

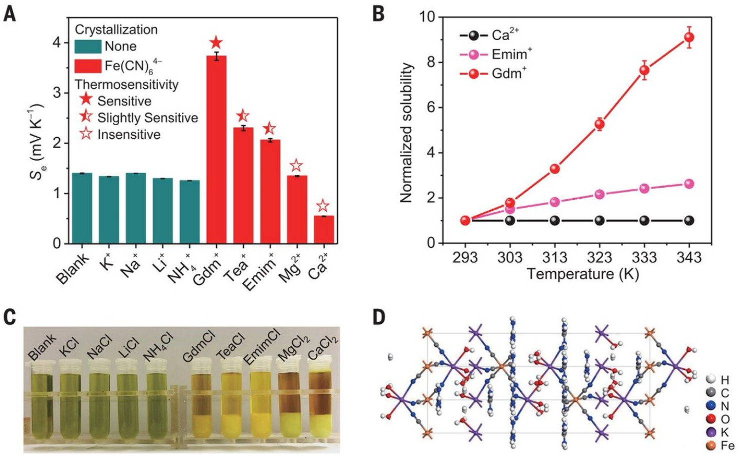

Figure 5: Various additive-induced enhancements of the Seebeck effect in the TC-LTC.

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Improvement of V_{oc} and ΔC_r

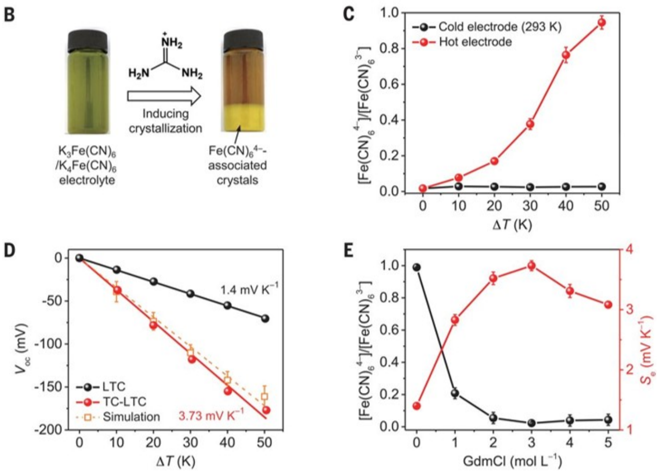

Figure 6: Open-circuit voltage (V_{oc}) and Concentration ratio difference (ΔC_r) with different ΔT and Gdm^+ concentration.

Thermoelectric performance of the TC-LTC

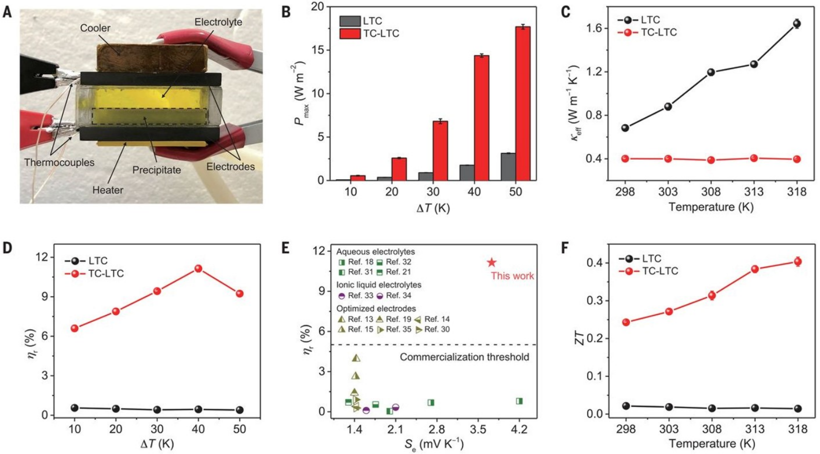

Figure 7: (B) Maximum power density (C) Effective thermal conductivity (D) Carnot-relative efficiency (E) η_r and S_e for various LTC systems (F) ZT value at different temperatures (T_c controlled at 293 K)

TC-LTC module

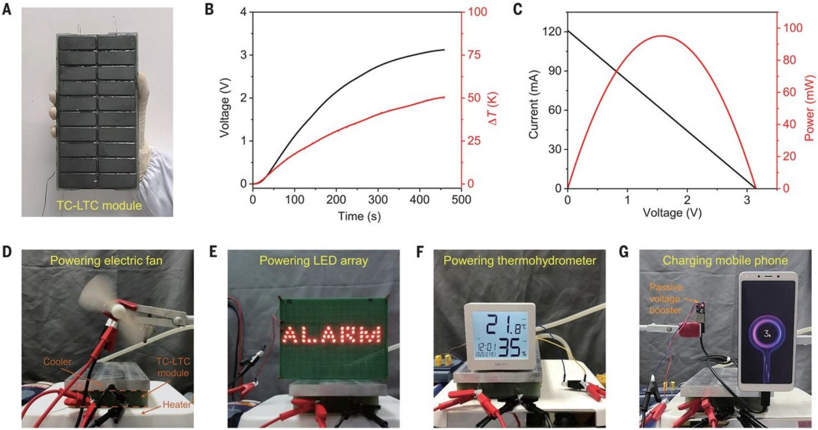

Figure 8: (A) TC-LTC module containing 20 units in series (B) Real-time voltage curves (black) of the module with an increase in ΔT. (C) Polarization curve at $\Delta T = 50\,\mathrm{K}$. (D) to (G) Real applications.

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Conclusions

- This paper used a thermosensitive crystallization and dissolution process to induce a persistent concentration gradient of redox ions, a highly enhanced Seebeck coefficient (3.73 millivolts per kelvin), and suppressed thermal conductivity in LTCs.
- As a result, the work achieved a high η_r of 11.1% for LTCs near room temperature.