# Energy Harvesting Device

## Thermochemical Cell based on Host-Guest Chemistry generating electricity from Room-Temperature Heat

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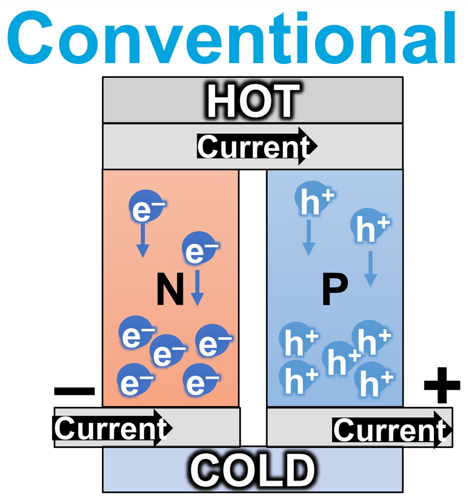
## 1. Introduction & Background

Over 60% of energy becomes heat loss without any work at room temperature range and it has been hardly utilized.

"Thermal to Electric" energy harvesting technology at room-temperature range is expected for various wearable micro devices.

### Conventional Technology

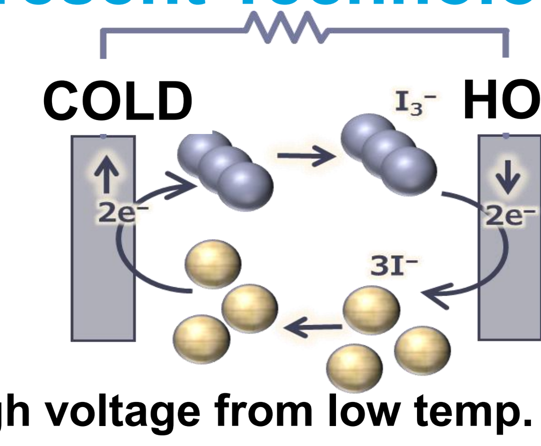




× Low performance at room temp.
× Low voltage per cell : complex device
× Toxic and rare atomic elements

**Thermoelectric Device**

### Present Technology Field

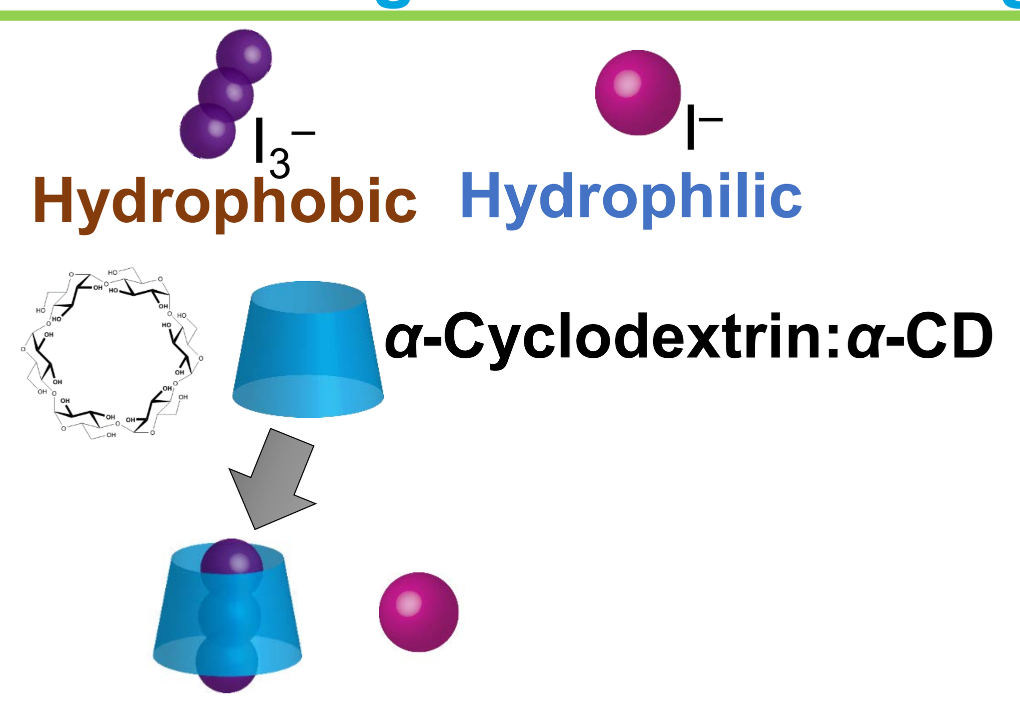



○ High voltage from low temp. heat flow (HighSeebeck coefficient : in order of mV/K )
○ Low cost and non-toxic materials
○ Simple system assembly and easy upsizing

**Thermochemical Cell**

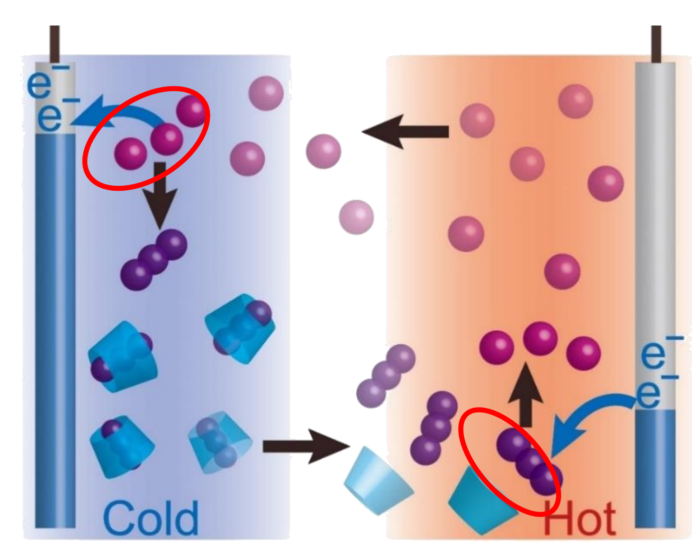
## 2. Key Features : Principle of the Invention

### Two Strategies to achieve High Concentration Gradient of Redox Species




$$E = E_f + \frac{RT}{2F}\ln\frac{[I_3^-]}{[I^-]^3}$$

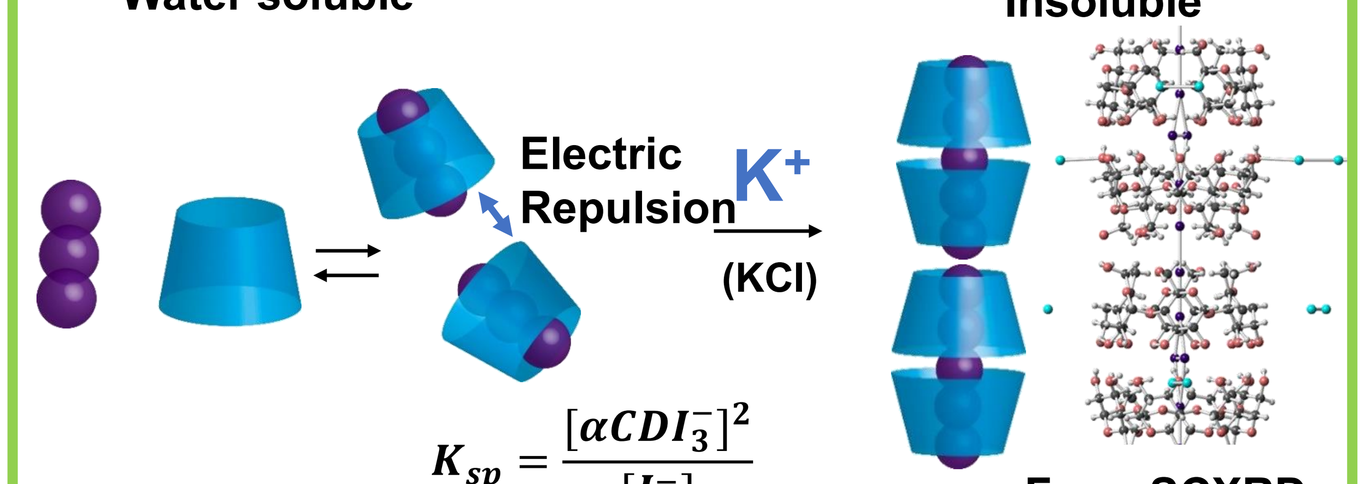
Selective capture of redox species




Low T : $I_3^-$ Captured
Negative potential Shift

High T : $I_3^-$ Released
Positive Potential Shift

**Thermocell System based on Supramolecular Chemistry**




$$K_{sp} = \frac{[\alpha CDI_3^-]^2}{[I^-]}$$

Cold : $I_3^-$ incorporated into precipitation
Hot : $I_3^-$ dissolved and eliminated

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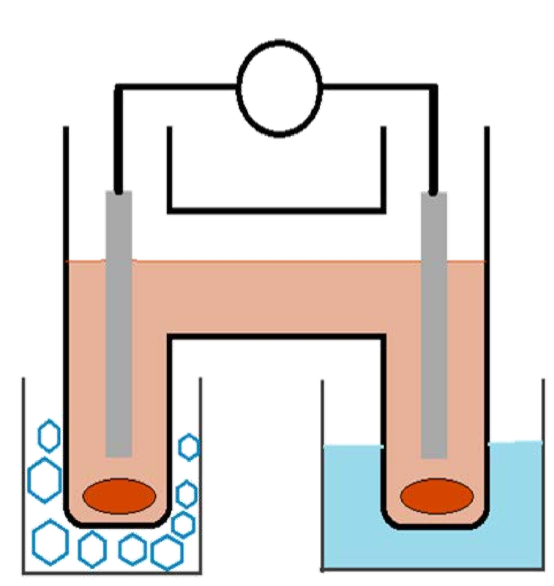
Large difference of $[I_3^-]$

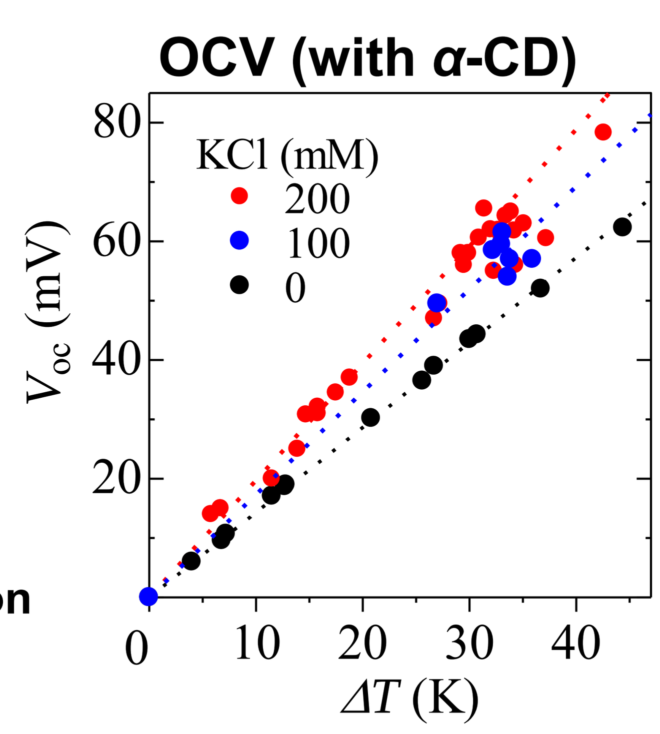
**Effect of KCl on Precipitation**

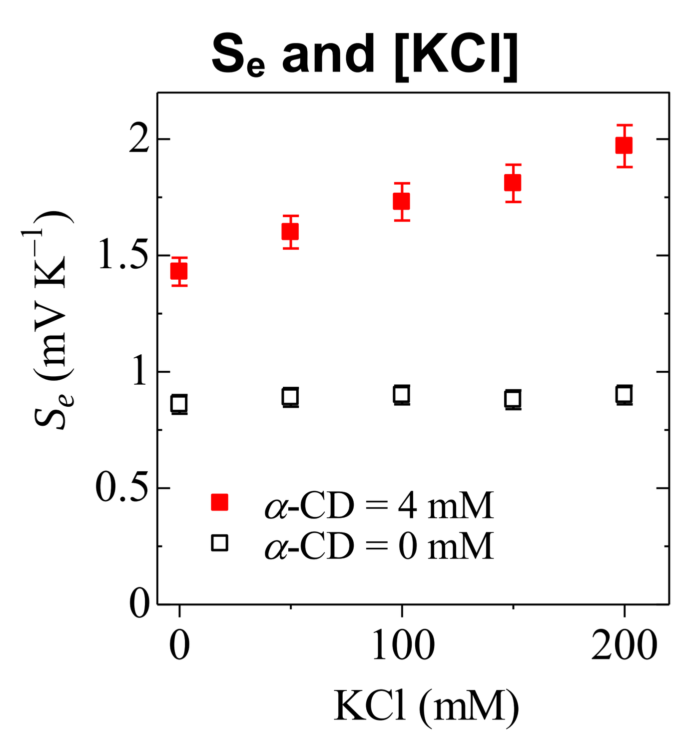
## 3. Experiment Data and Estimated Characteristics




Initial Concentration
$[KI_3]$ = 2.5 mM
[KI] = 10 mM
[α-CD] = 4 mM

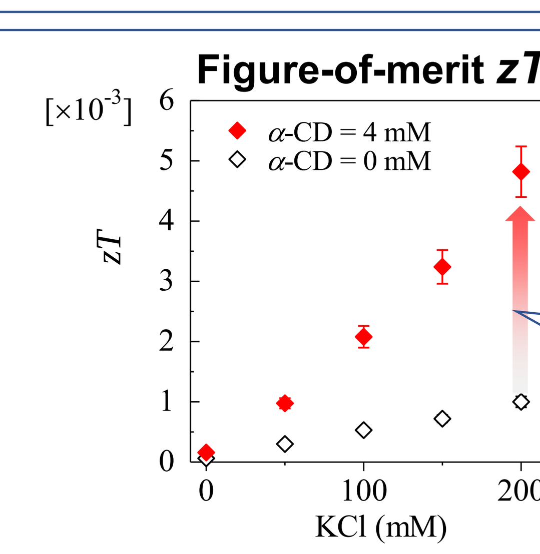
**Experimental Cell**




$KI_3$/KI Solution 0.86 mV K⁻¹ → α-CD → Host–Guest 1.43 mV K⁻¹ → KCl → Aggregated 1.97 mV K⁻¹

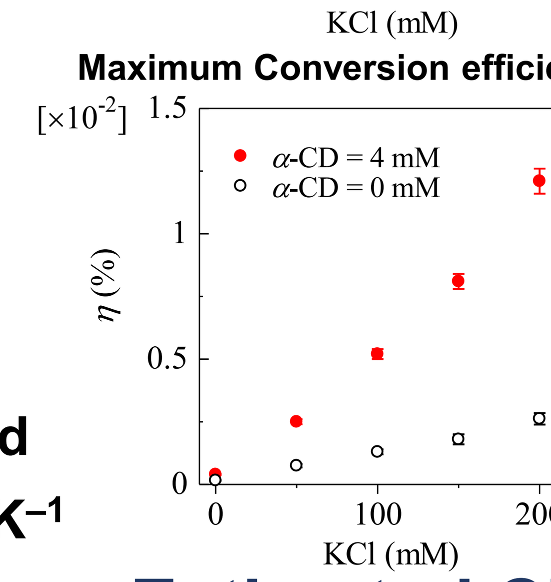
**Seebeck Coefficient Enhancement**




$$zT = \frac{\sigma S_e^2}{\kappa}T$$

$$zT = 5\times10^{-3}$$

5 times Enhancement




$$\eta = \frac{\Delta T}{T_h}\frac{\sqrt{1+zT}-1}{\sqrt{1+zT}+\frac{T_c}{T_h}}$$

$$\eta = 0.012\%$$

1) Snyder & Toberer, *Nature Mater.*, 2008

**Estimated Characteristics**

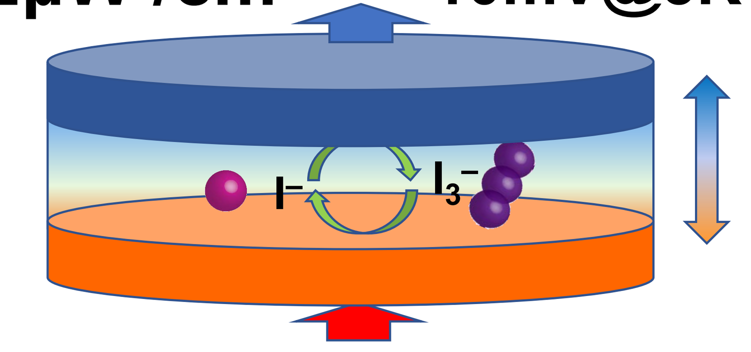
## 4. Application Examples

○ Wearable Heat Sensor or Energy Source
The sensors or electric power generators are driven by the human body heat.

○ Heat Pump System with Electric Generator
The heat transfer and thermoelectric generation are available at the same time.

○ Energy Harvesting for low-temperature Heat Loss
The energy recovery from underused heat loss in factories, homes, shopping malls is efficiently possible.

~2μW /cm² 10mV@5K




**Coin Cell Structure**

## 5. Patent Licensing Available

Patent No.: WO2017/155046 (JP, US, EP, CN)
JST/ IP Management and Licensing Group
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