Thermo-Electrochemical Cell Development by Using Temperature Responsive Nanogel

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About 60% of energy in power stations is discarded as waste heat and difficult to be recycled. If it is possible to convert low-temperature heat (<100 °C) into electricity, it'll be expected as a new power generation process utilizing large-scale unused energy. Although a method using the Seebeck effect of thermoelectric elements to convert low temperature thermal energy into electricity has been reported 1), the low conversion efficiency and high cost are problems. Therefore, development of inexpensive and highly efficient thermoelectric conversion material and conversion process is required (Fig. 1a).

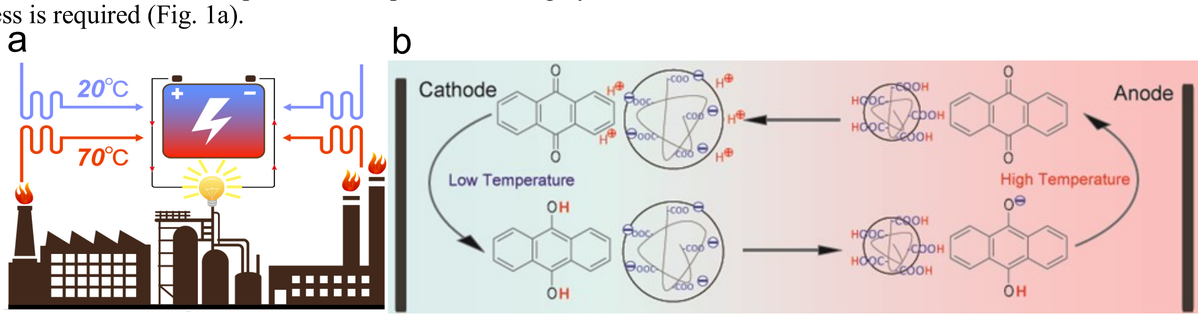

Fig. 1 Energy loss recycling of thermal power plant (a) and Reaction of the NPs and redox species (b)

We have developed a temperature responsive nanogel particles (NPs) using proton imprint method. 2) The NPs can reversibly change the pKa in different temperature due to hydrophilic and hydrophobic phase transition. In this study, we developed a thermo-electrochemical battery using the proton-imprinted NPs (Fig. 1b). By optimizing the combination of the NPs and redox species such as Anthraquinone-2, 7-disulfonate (AQDS), it was revealed that a potential difference of about 280 mV can be obtained from a temperature difference of 50 °C (Fig. 2).

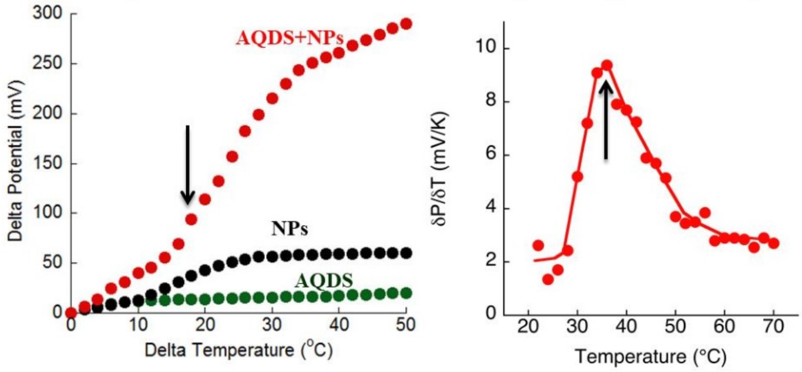

Fig. 2 Temperature difference effect on potential difference (a) and potential gradient of AQDS (b)

It became clear that the potential difference can be increased by controlling the redox state of redox species, especially near the phase transition temperature of NPs. At the same time, we synthesized a variety of NPs containing acrylic acid monomer and acrylamide monomer, which can exhibit different changes of pKa under a certain temperature difference. Through the control experiment, we can make clear the change trend of potential difference. In addition, we designed a flow battery device containing two cells with large area platinum electrodes for measuring the energy conversion efficiency of the thermoelectric cell during actual discharge. The experiment confirmed the high efficiency and practicality of the Redox-NPs thermo-electrochemical cell.

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