Supporting Information

Energy Consumption in Capacitive Deionization for Desalination: A Review

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1. Calculation of Parameters

Desalination capacity (salt removal capacity) is defined as the weight of salt removal per unit weight of active material, and it is calculated as Equation (S1):

$$SAC = \frac{\Delta C \times V}{m}. \quad \text{(S1)}$$

As above, *SAC* is the desalination capacity (mg·g^{-1}), ΔC refers to the salt concentration change in the feed solution (mg·L^{-1}) during charging, *V* stands for the volume of the feed solution (L), and *m* denotes the weight of the active material (g). On the other hand, energy consumption is the energy consumed per gram of salt removal, and it is calculated as Equation (S2):

$$W = \frac{\int (I \times U)\, dt}{\Delta C \times V}. \quad \text{(S2)}$$

As above, *W* is the energy consumption (Wh·g_{NaCl}^{-1}), and *I* and *U* denote the instantaneous current (A) and voltage (V) during charging, respectively. Charge efficiency refers to the ratio of the charge amount correspondent to the actual salt removal and the overall consumed charge amount, and it is calculated as Equation (S3):

$$\Lambda = \frac{\Delta C \times V \times F}{\int I\, dt \times 1000 \times M_{NaCl}}. \quad \text{(S3)}$$

As above, *F* is the Faraday constant (96,485 C·mol^{-1}), *t* demonstrates the time consumed in the deionization process, and M_{NaCl} is the molar mass of sodium chloride (g·mol^{-1}). Besides, deionization is also a process of energy storage, thus recovered energy is the energy regenerated per unit of salt removal in the desalination device. The calculation of recovered energy is similar to the energy consumption as shown in Equation (S4):

$$ER = \frac{\int (I_R \times U_R)\, dt}{\Delta C \times V}. \tag{S4}$$

As above, ER is the recovered energy ($Wh \cdot g_{NaCl}^{-1}$), and I_R, U_R, and ΔC denote the instantaneous current (A), voltage (V), and concentration change during discharging, respectively. Energy recovery rate (ERR) is the ratio of recovered energy and energy consumption, which is calculated as follows:

$$ERR = \frac{ER}{W}. \tag{S5}$$

2. Deduction of the Relationship of Parameters

In the capacitive deionization (CDI) process of constant voltage mode, the energy consumption is calculated as Equation (S6):

$$W = \frac{U \times \int I dt}{\Delta C \times V}. \tag{S6}$$

As above, U is the voltage applied in the CDI cell. Together with Equation (S3), the product of energy consumption and charge efficiency is demonstrated as follows:

$$W\Lambda = \frac{U \times F}{3600 \times M_{NaCl}}. \tag{S7}$$

As above, U, F, and M_{NaCl} are all constant parameters. As such, we could figure out the energy consumption is in inverse proportion with charge efficiency.

3. Supplementary Table

Table S1. The comparison of CDI and MCDI.

<table>
<tr><td></td><td colspan="2">Incorporation of ion-exchange membrane</td><td colspan="2">Charge efficiency</td><td>Energy consumption</td><td>Desalination capacity</td></tr>
<tr><td>CDI</td><td colspan="2">no</td><td colspan="2">lower</td><td>higher</td><td>lower</td></tr>
<tr><td>MCDI</td><td colspan="2">yes</td><td colspan="2">higher</td><td>lower</td><td>higher</td></tr>
<tr><td></td><td>Electrode material</td><td>Electric intensity</td><td>Initial salinity</td><td>Energy consumption</td><td>Desalination capacity</td><td>Reference</td></tr>
<tr><td rowspan="5">CDI</td><td>activated carbon</td><td>1.2 V</td><td>200 ppm</td><td>1.55 $Wh\cdot g_{NaCl}^{-1}$</td><td>2.27 $mg\cdot g^{-1}$</td><td>[1]</td></tr>
<tr><td>activated carbon</td><td>1.4 V</td><td>600 ppm</td><td>1.17 $Wh\cdot g_{NaCl}^{-1}$</td><td>14.9 $mg\cdot g^{-1}$</td><td>[2]</td></tr>
<tr><td>activated carbon</td><td>1.2 V</td><td>10 mM</td><td>1.04 $Wh\cdot g_{NaCl}^{-1}$</td><td>~3 $mg\cdot g^{-1}$</td><td>[3]</td></tr>
<tr><td>carbon</td><td>1.2 V</td><td>20 mM</td><td>~0.71 $Wh\cdot g_{NaCl}^{-1}$</td><td>---</td><td>[4]</td></tr>
<tr><td>activated carbon</td><td>1.2 V</td><td>20 mM</td><td>0.97 $Wh\cdot g_{NaCl}^{-1}$</td><td>2.37 $mg\cdot g^{-1}$</td><td>[5]</td></tr>
<tr><td rowspan="5">MCDI</td><td>activated carbon</td><td>1.2 V</td><td>200 ppm</td><td>less than half of that of CDI in [1]</td><td>3.54 $mg\cdot g^{-1}$</td><td>[1]</td></tr>
<tr><td>activated carbon</td><td>1.4 V</td><td>600 ppm</td><td>0.92 $Wh\cdot g_{NaCl}^{-1}$</td><td>20.0 $mg\cdot g^{-1}$</td><td>[2]</td></tr>
<tr><td>porous carbon</td><td>1.2 V</td><td>20 mM</td><td>~0.56 $Wh\cdot g_{NaCl}^{-1}$</td><td>---</td><td>[6]</td></tr>
<tr><td>activated carbon</td><td>1.0 V</td><td>10 mM</td><td>~0.49 $Wh\cdot g_{NaCl}^{-1}$</td><td>~13.6 $mg\cdot g^{-1}$</td><td>[7]</td></tr>
<tr><td>biowaste carbon</td><td>1.2 V</td><td>2500 ppm</td><td>0.63 $Wh\cdot g_{NaCl}^{-1}$</td><td>38 $mg\cdot g^{-1}$</td><td>[8]</td></tr>
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References

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