Electronic supplementary materials

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Hole-growth phenomenon during pyrolysis of a cation-exchange resin particle

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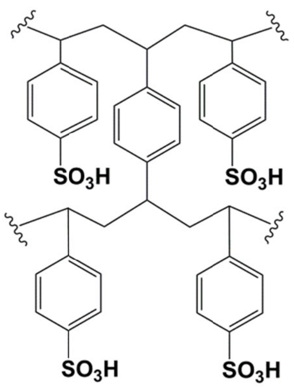


Fig. S1 Structure of the strongly acidic cation exchange resin

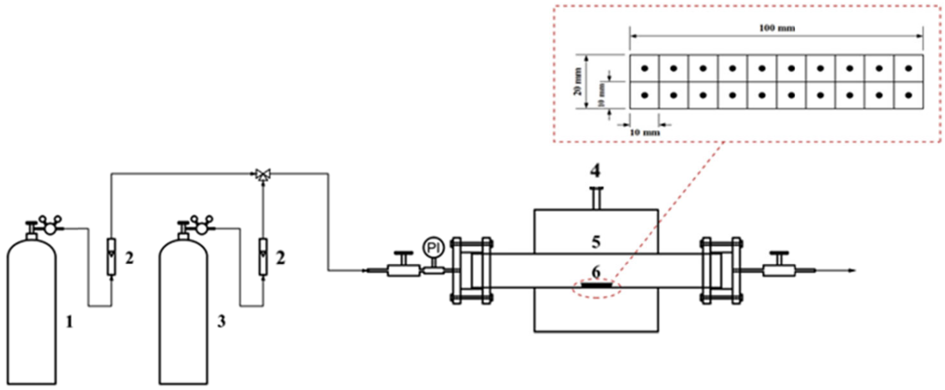
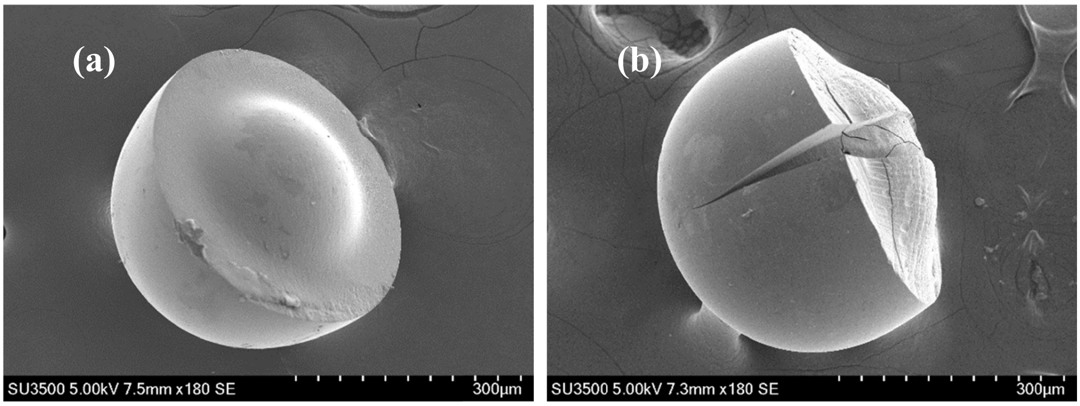


Fig. S2 Experimental apparatus for the pyrolysis of cation exchange resin. 1-Oxygen cylinder; 2-Rotameter; 3-Nitrogen cylinder; 4-Thermocouple; 5-Tube furnace; 6-Crucible



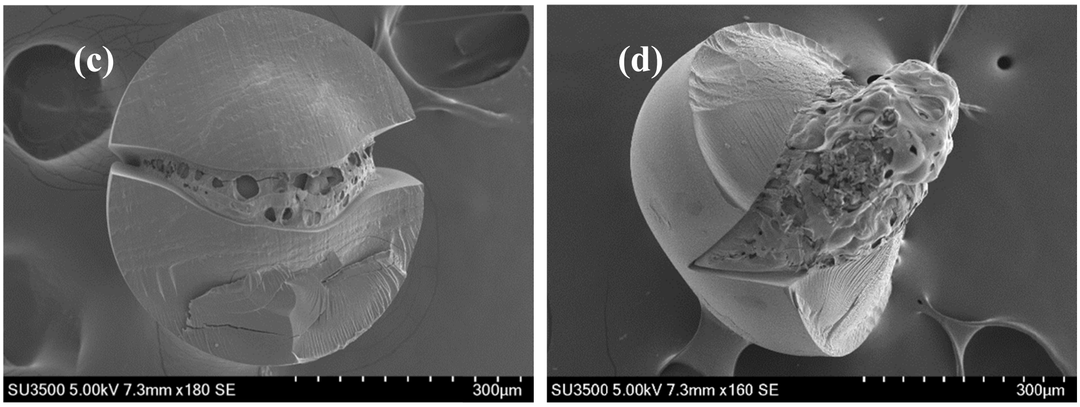


Fig. S3 Morphologies of hemispherical resins pyrolyzed at 450 ℃ in 3% O_2 for (a) 10 min, (b) 15 min, (c) 20 min, and (d) 30 min

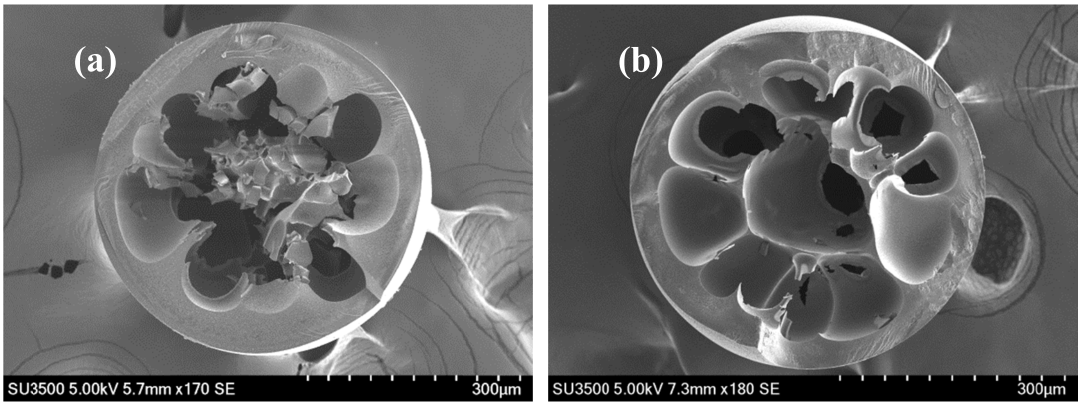


Fig. S4 Morphologies of (a) Co-doped resin and (b) pure resin pyrolyzed at 450 ℃ in 3% O_2 for 30 min

Table S1 Thermophysical properties and boundary conditions of resin particle in simulation.

	This work	**Reference values**
Specific heat capacity, J/kg·K	1500	1000-2000 [1]
Thermal conductivity, W/m·K	0.04	0.03-0.05 [2]
Specific heat of pyrolysis, J/g	2000	1000-3000 [3-5]
Density, kg/m^3	1475	—
Environment temperature, ℃	450	—
Initial particle temperature, ℃	25	—

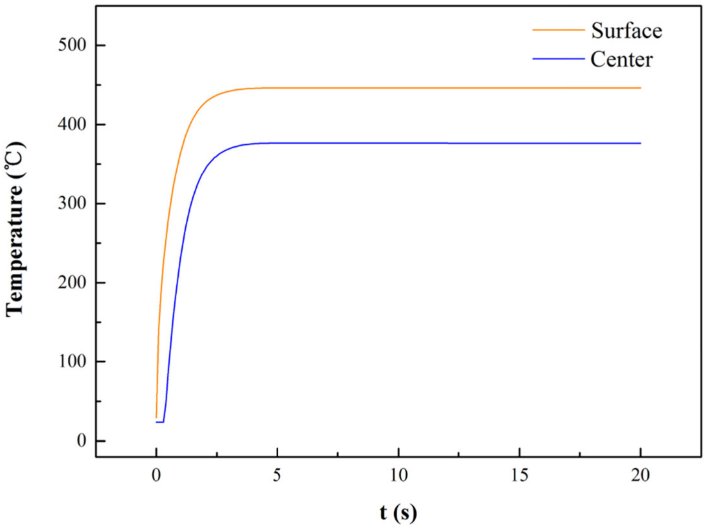


Fig. S5 Temperature changes on the surface and center of the resin particle obtained by simulation

$$q_0 = h \cdot (T_{\mathrm{ext}} - T) \tag{S1}$$

$$\rho C_p u \cdot \nabla T + \nabla \cdot (-k \nabla T) = Q + Q_{\mathrm{ted}} \tag{S2}$$

$$Q_{ted} = \frac{P}{V} \tag{S3}$$

where q_o is the heat flux (W/m^2), h is the natural convection heat transfer coefficient (W/m^2·K), T_{ext} is the ambient temperature (K), T_2 is the particle temperature (K), ρ is the heat flux density (kg/m^3), C_p is the heat flux specific heat capacity (J/kg·K), u is the flow velocity field (m/s), ∇T is the temperature gradient (K/m), k is the thermal conductivity (W/m·K), Q_{ted} is the increased heat source (W/m^3), Q is the ambient heat transfer (W/m^3), P is the heat consumption rate of the heat source (W), and V is the Endothermic volume (m^3).

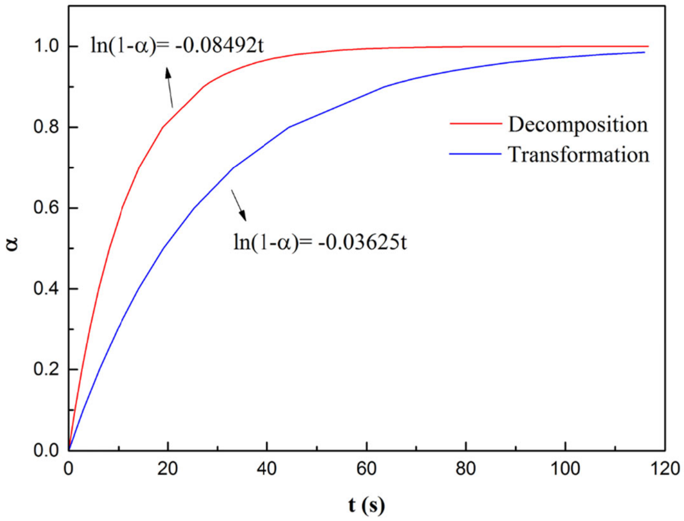


Fig. S6 Relationships between the conversion rate and time in the decomposition process and transformation process of sulfonic acid groups

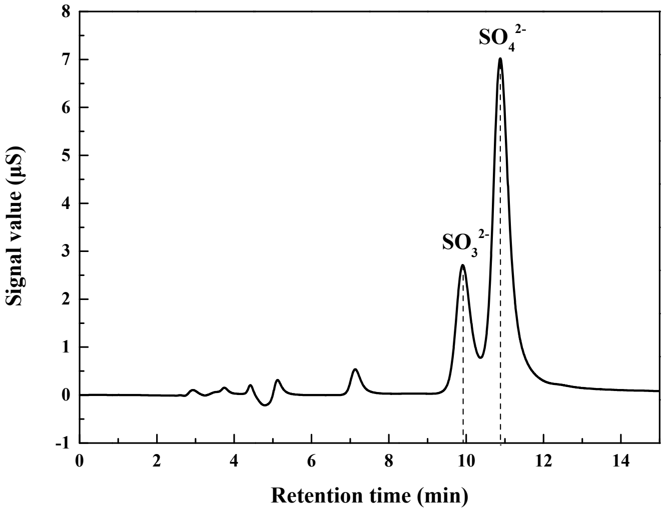


Fig. S7 Chromatograms of sulfite ion and sulfate ion in the solution.

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