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A five-electrode capacitively coupled contactless conductivity detector with low limit of detection

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TIC^{4}D input signal parameter optimization

The results of TIC^{4}D frequency optimization are shown in Figure S1A. It can be seen that the effect of frequency on KCl solutions of different concentrations is different. The response signal values of 10^{-9} M to 10^{-4} M KCl solutions and ultrapure water decrease with increasing frequency, while the response signal values of 10^{-3} M KCl solutions increase with increasing frequency. It is worth noting that when the frequency is lower than 30 kHz, the response signal value of 10^{-4} M KCl solution is higher than the response signal value of 10^{-3} M KCl solution. This may be because when the concentration of the solution to be measured is high, the response signal reaches saturation, resulting in a decrease in the response signal. After comprehensive consideration, we have selected 40 kHz as the signal input frequency. The larger the amplitude provided by the signal generator, the larger the response signal value. However, the maximum amplitude of the phase locked amplifier is 20 Vpp and the maximum range of the multimeter is 10 V. Therefore, we optimize the amplitude within the range of the phase locked amplifier and the multimeter. As the amplitude increases, the response signal value of TIC^{4}D also increases. It indicates that an appropriate increase in amplitude can help improve the sensitivity of the detector, and we ultimately selected 2 Vpp as the input signal amplitude.

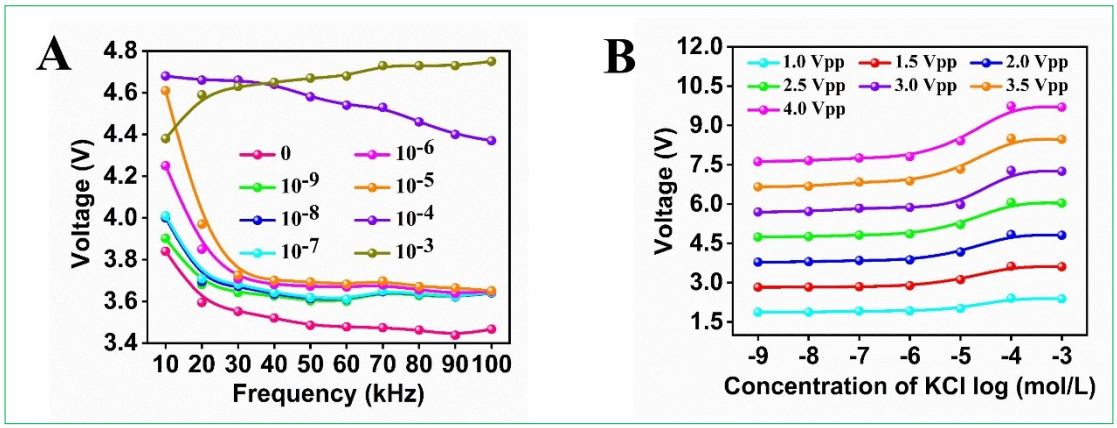

Figure. S1 TIC^{4}D input signal parameter optimization results. (A) Frequency optimization; (B) Amplitude optimization.

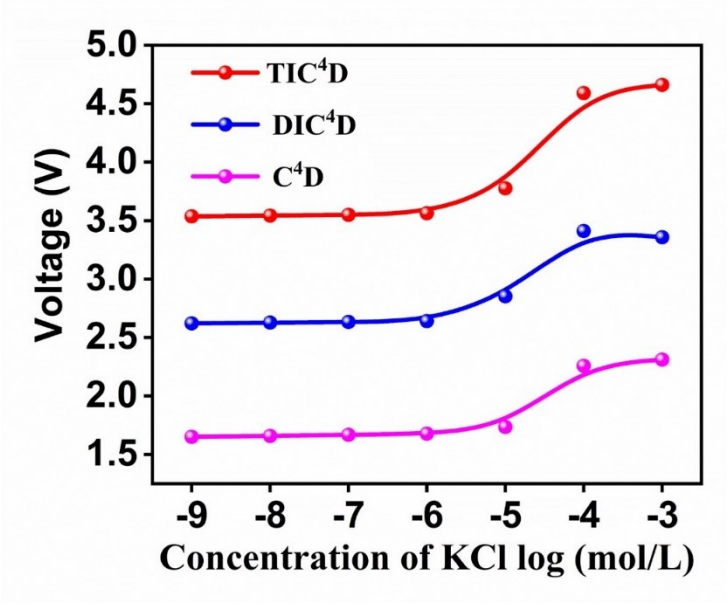

Figure. S2 The response curves of C^4D, DIC^4D and TIC^4D to KCl solution with a concentration range of 10^{-9} M to 10^{-3} M.

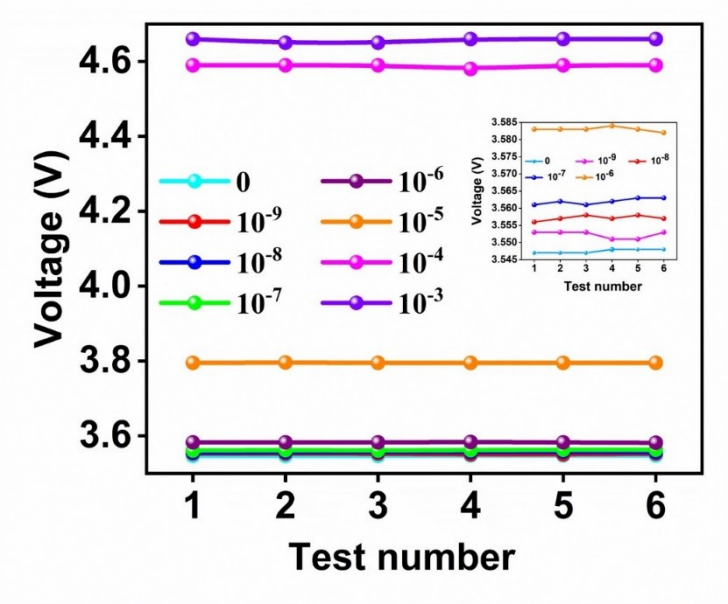

Figure. S3 The response reproducibility of TIC^4D. The response curves of TIC^4D to KCl solution with a concentration range of 10^{-9} M to 10^{-3} M.

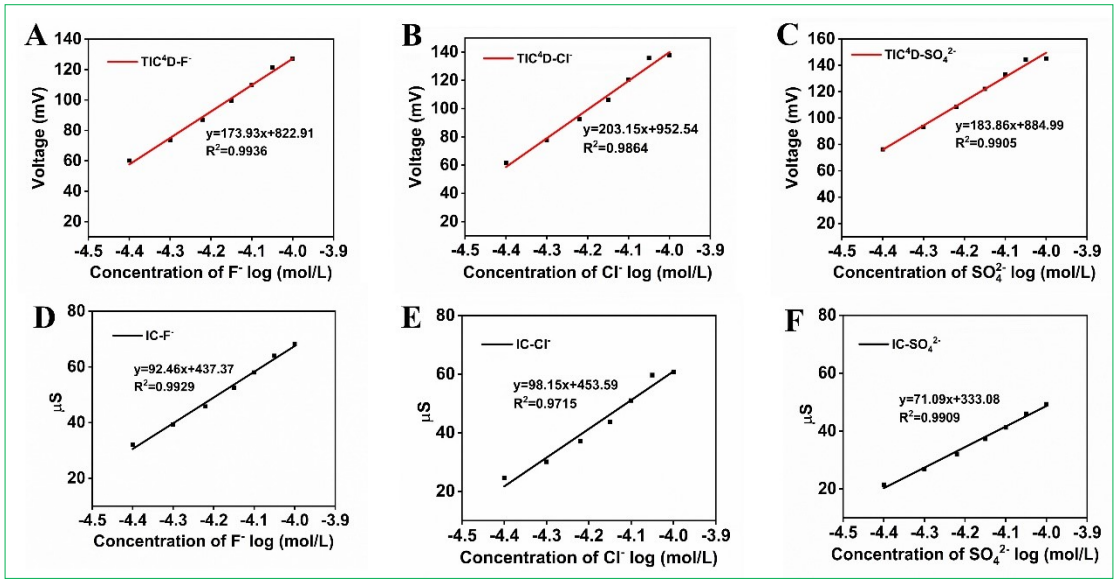

Figure. S4 Linear diagram of TIC^{4}D combined with ion chromatography. (A) The relationship between F^- response signal and concentration measured by TIC^{4}D; (B) The relationship between Cl^- response signal and concentration measured by TIC^{4}D; (C) The relationship between SO_4^{2-} response signal and concentration measured by TIC^{4}D; (D) The relationship between F^- response signal and concentration measured by ion chromatography; (E) The relationship between Cl^- response signal and concentration measured by ion chromatography; (F) The relationship between SO_4^{2-} response signal and concentration measured by ion chromatography.

SIDC^{4}D input signal parameter optimization

The frequency optimization of SIDC^{4}D is shown in Figure S5A. The response of ultrapure water and 10^{-9} M to 10^{-5} M KCl solutions gradually decreases with increasing frequency. The response signal values of 10^{-4} M KCl solution and 10^{-3} M KCl solution first increase and then decrease with increasing frequency, reaching the maximum value at a frequency of 50 kHz. Therefore, based on comprehensive considerations, we choose 50 kHz as the optimal frequency for detection. Amplitude optimization is shown in Figure S5B. Amplitude optimization is performed in the range of 1 Vpp to 10 Vpp. The larger the amplitude, the greater the signal response value. SIC^{4}D has six input signals. It can be seen that the greater the number of input signals, the greater their response value. To compare with SIC^{4}D, we choose 1Vpp as the detection amplitude.

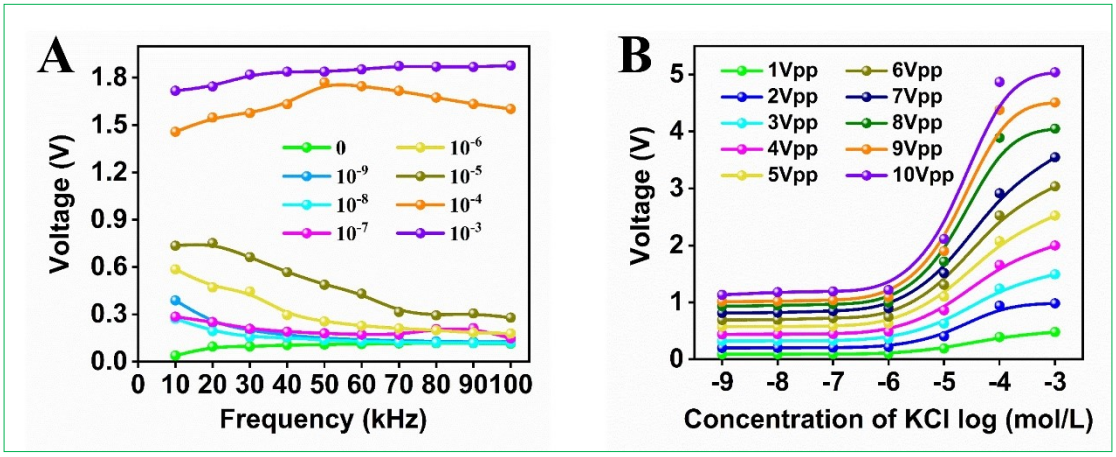

Figure. S5 SIDC^{4}D input signal parameter optimization results. (A) Frequency optimization; (B) Amplitude optimization.

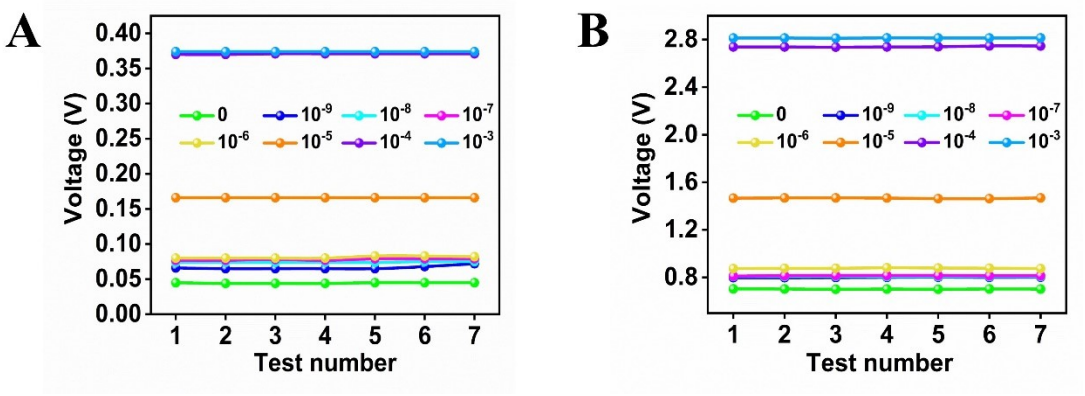

Figure. S6 The response reproducibility of SIDC^{4}D at different amplitudes. (A)The response curves of SIDC^{4}D to KCl solution with a concentration range of 10^{-9} M to 10^{-3} M at an amplitude of 1 Vpp. (B) The response curves of SIDC^{4}D to KCl solution with a concentration range of 10^{-9} M to 10^{-3} M at an amplitude of 6 Vpp.