

## Supporting Information

### Ultrasound-assisted green and efficient extraction of polysaccharides from *Chlorella vulgaris* using deep eutectic solvents and improving their performance

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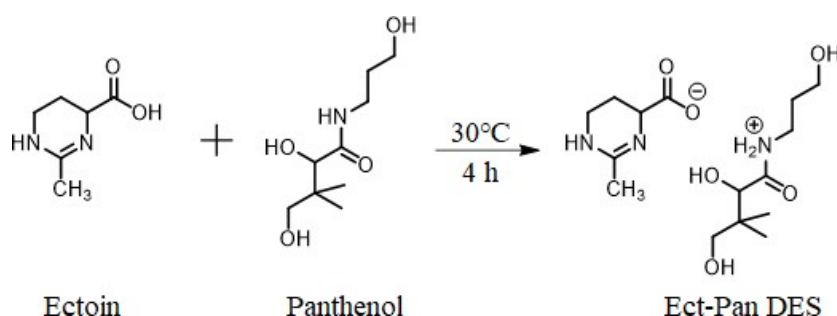
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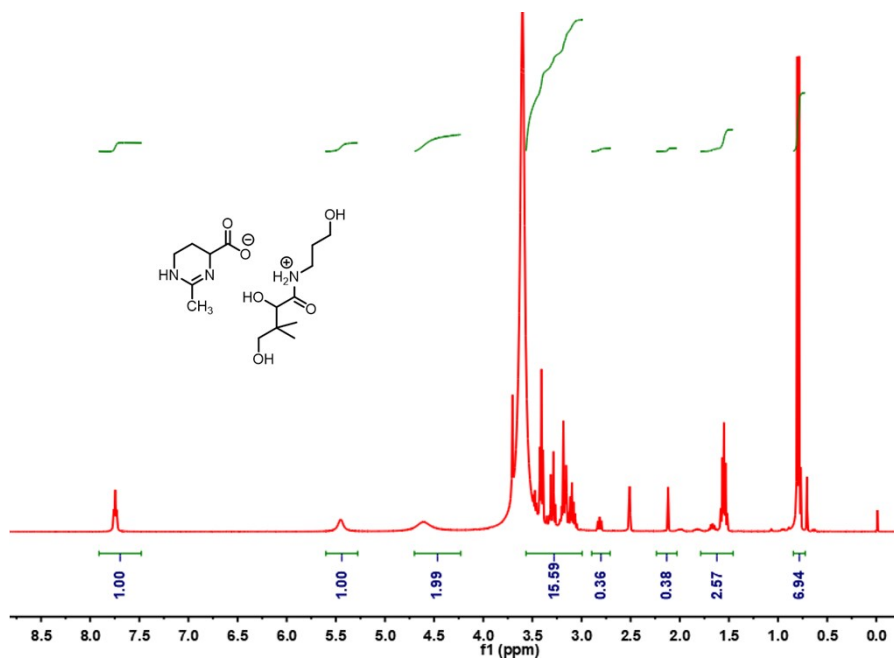
The preparation process diagram of DES formed by ectoin and panthenol (Figure S1). In Figure S2, 7.74 ppm (-COOH, carboxyl group on ectoin, 1H), 5.45 ppm (-COOH, hydroxyl group on panthenol, 1H), 4.61 ppm (-COOH, hydroxyl group on panthenol, 2H), 3.7-3.47 ppm (-CH<sub>2</sub>-, methylene on panthenol and ectoin, 8H), 3.42-3.06 ppm (-CH<sub>2</sub>-, -CH panthenol and methylene on ectoin, 6H), 2.83-2.79 ppm (-NH-, imine on panthenol, 1H), 2.11 ppm (-NH-, imine on epichlorohydrin, 1H), 1.58-1.51 ppm (-CH<sub>2</sub>-, methylene on panthenol and ectoin, 2H), 0.8-0.7 ppm (-CH<sub>3</sub>, methyl on panthenol, 6H). In Figure S3, 173.96 ppm (s), 159.73 ppm (s), 77.41 ppm (s), 75.60 ppm (s), 69.92 ppm (s), 68.47 ppm (s), 59.12 ppm (s), 58.59 ppm (s), 53.38 ppm (s), 37.47 ppm (s), 35.97 ppm (s), 32.34 ppm (s), 21.28 ppm (s), 20.56 ppm (s), 18.45 ppm (s). In Figure S4, The red circle represents the force between ectoin and panthenol, while the black diagonal represents the force within the molecule.

In Figure S5, 3300cm<sup>-1</sup> was the stretching vibration peak of -OH, and the stretching vibration peak of Ect-Pan DES significantly widened, indicating the formation of Ect-Pan DES. The stretching vibration peak of 1620cm<sup>-1</sup> was -NH- and the bending vibration peak of 1000cm<sup>-1</sup> was -CH<sub>3</sub>. Ect-Pan DES retains the stretching vibration peak of -NH- and the bending vibration peak of -CH<sub>3</sub>, indicating the formation of Ect-Pan DES between ectoin and panthenol. In addition, the differences in infrared spectra of Ect-Pan DES with different molar ratios are not very significant.

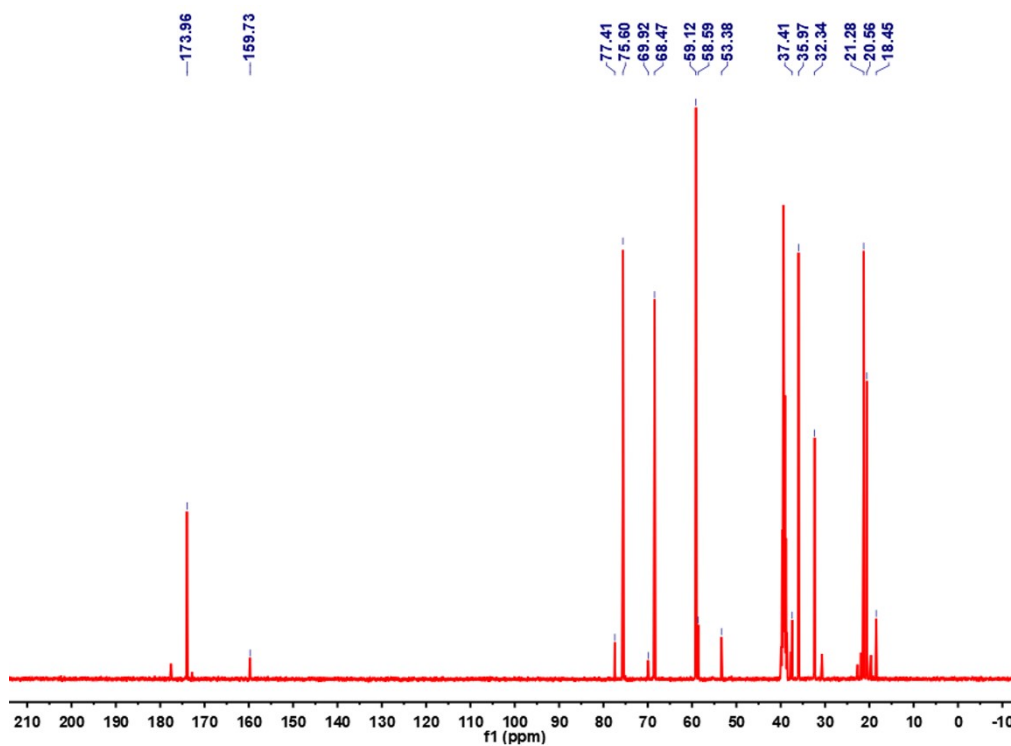
Therefore, NMR and FTIR results can indicate that DES was formed between ectoin and panthenol through intermolecular forces.



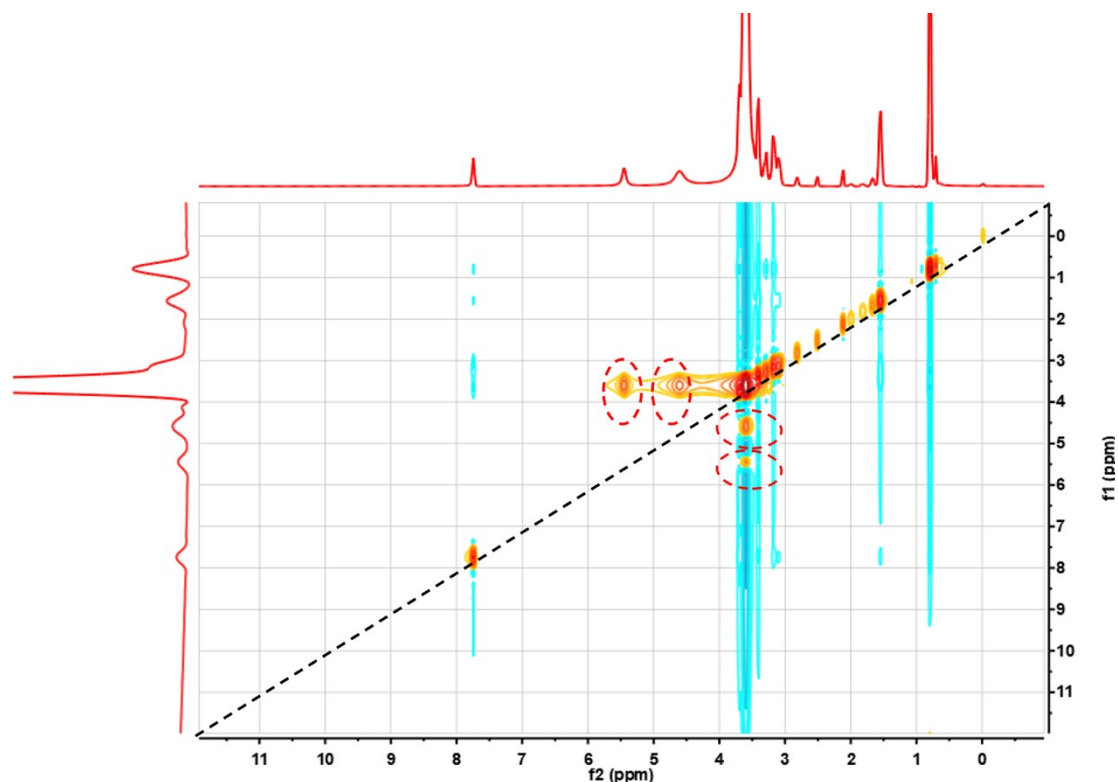
**Figure S1.** Synthesis diagram of Ect-Pan DES.



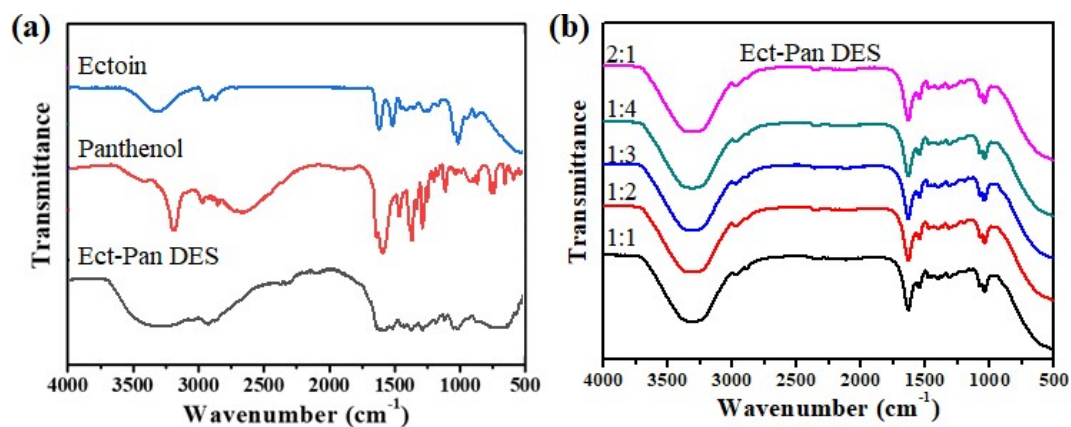
**Figure S2.**  $^1\text{H}$  NMR spectrum of Ect-Pan DES.



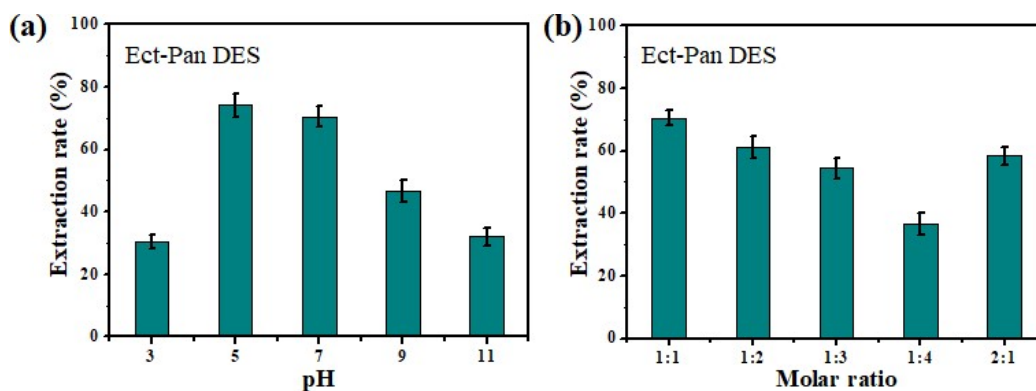
**Figure S3.**  $^{13}\text{C}$  NMR spectrum of Ect-Pan DES.



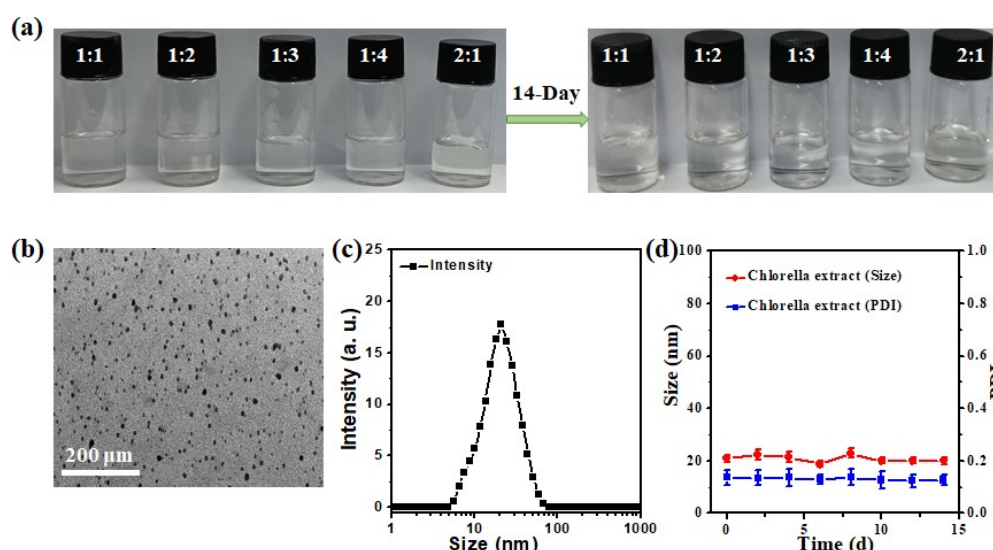
**Figure S4.** NOESY spectrum of Ect-Pan DES (The red circle in the figure represents the interaction force between ectoin and panthenol).



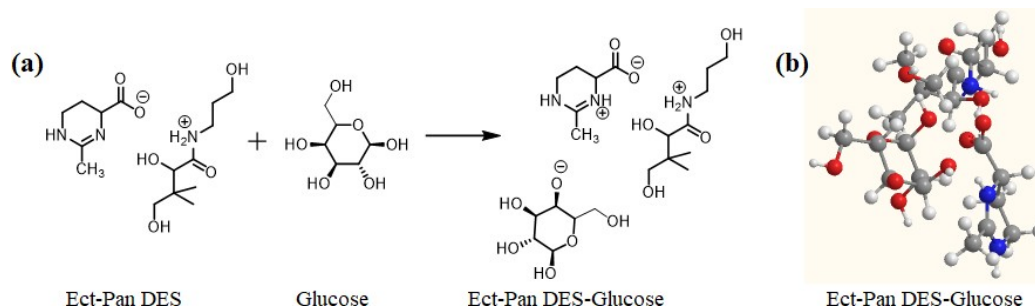
**Figure S5.** FTIR spectra of (a) ectoine, panthenol, and (b) different molar ratios of Ect-Pan DES.



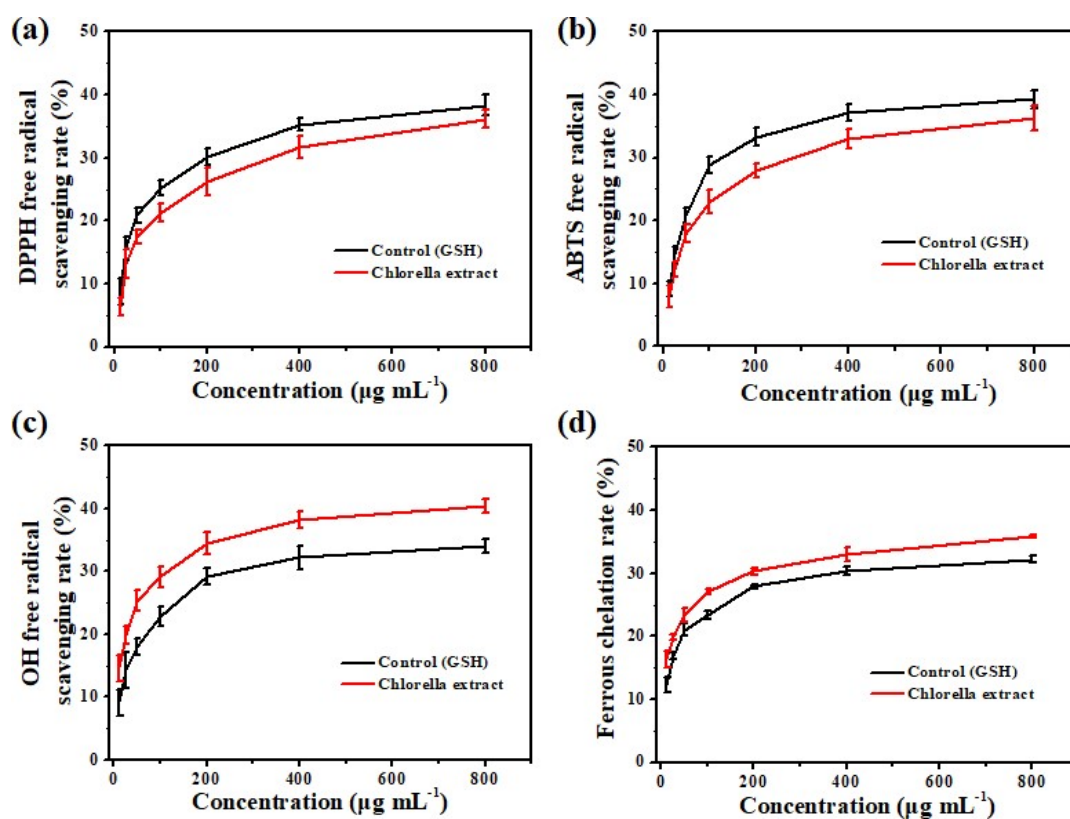
**Figure S6.** Extraction efficiency of Ect-Pan DES with different pH values and molar ratios.



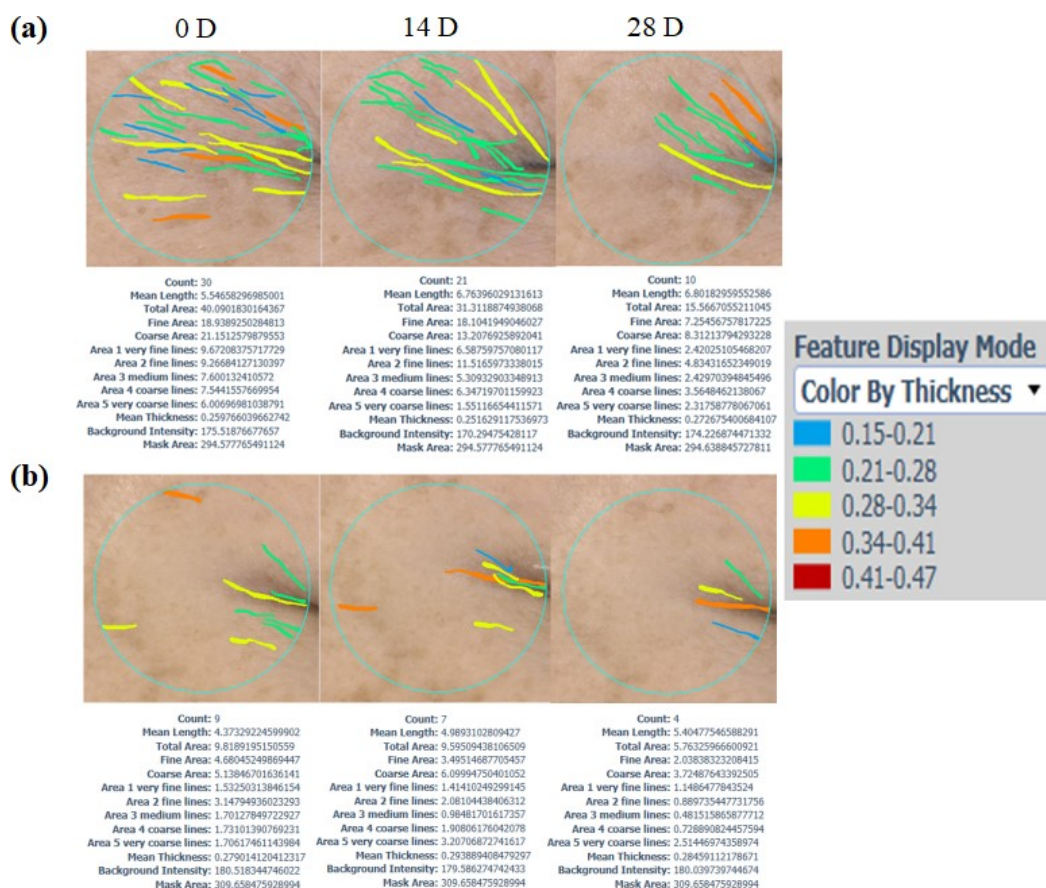
**Figure S7.** (a) Digital photo images of Ect-Pan DES. (b) TEM image, (c) particle size image, and (d) stability image of polysaccharides extracted from *Chlorella vulgaris* using Ect-Pan DES.



**Figure S8.** The structural formula (a) and interaction forces (b) between Ect-Pan DES and glucose.



**Figure S9.** The abilities of Chlorella extract and GSH (control) to (a) DPPH free radical scavenging rate, (b) ABTS free scavenging rate, (c) OH free radical scavenging rate, and (d) ferrous chelation rate (n=3).



**Figure S10.** Facial wrinkles of different subjects (a, b), and the depth range of wrinkles represented by different wrinkle colors (right).

## References

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