

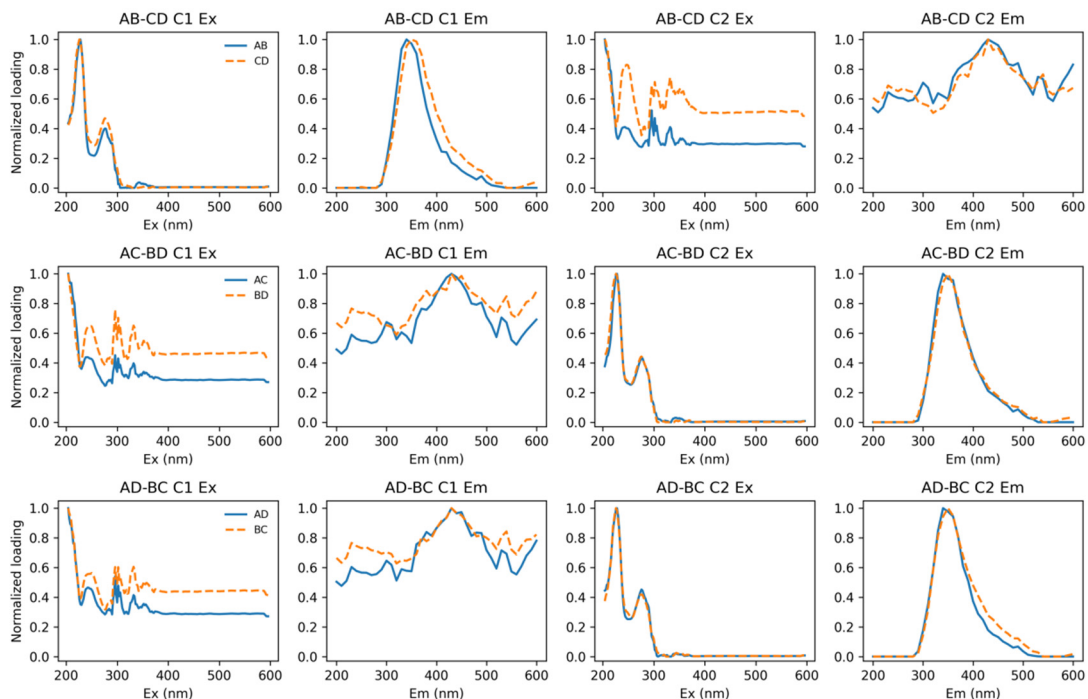


Figure S1. Split-half validation of the selected two-component PARAFAC model. Excitation and emission loading profiles of C1 and C2 obtained independently from the complementary datasets in the three S4C6T3 comparisons (AB-CD, AC-BD, and AD-BC) are overlaid. All matched excitation and emission loading profiles showed Tucker congruence coefficients (TCCs) ≥ 0.95 , with an overall minimum TCC of 0.971, confirming the reproducibility of the two-component solution.

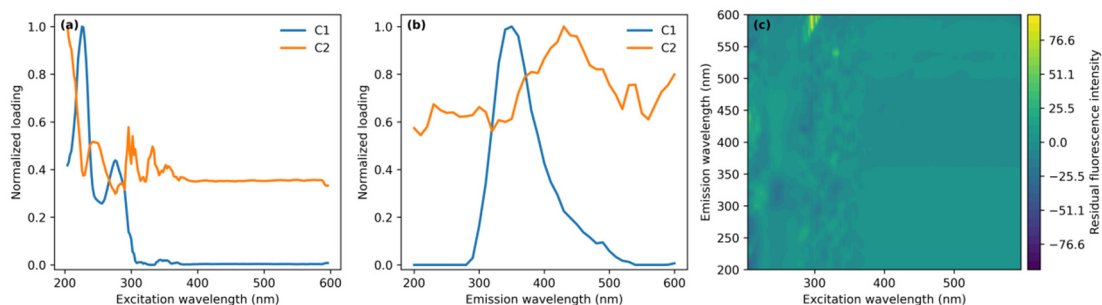


Figure S2. Spectral loadings and residual diagnostics of the selected two-component PARAFAC model. (a) Normalized excitation loading spectra and (b) normalized emission loading spectra of C1 and C2. C1 exhibited excitation/emission maxima at approximately 226/350 nm, whereas C2 exhibited maxima at approximately 204/430 nm. (c) Mean residual excitation-emission matrix after reconstruction by the selected two-component model.

Table S1. Comparison of two- to five-component PARAFAC models based on explained variance, core consistency (CORCONDIA), and S4C6T3 split-half validation. The two-component model was selected because it combined high explained variance, high core consistency, and complete split-half reproducibility. Split-half validation was considered satisfactory when all matched excitation and emission loading profiles had TCC ≥ 0.95 .

Components	Explained variance (%)	CORCONDIA (%)	Split-half validation	Minimum TCC
2	92.48	99.27	Pass	0.971
3	94.21	93.27	Fail	0.275
4	95.76	48.84	Fail	0.058
5	96.95	59.41	Fail	0.594