Self-assembled tryptophan-containing peptides for solubilization and stabilization of vitamins

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Abstract

Many essential vitamins, including riboflavin (B_2), retinol (A), cholecalciferol (D_3), and ascorbic acid (C), have poor aqueous solubility and are sensitive to light and oxidation, limiting their stability and formulation potential. Tripeptides, short chains of three amino acids, self-assemble via hydrophobic effects, hydrogen bonding, and π–π stacking, making them useful for functional materials. We studied two sequence-isomeric tripeptides, WKY and WYK, selected for their distinct aggregation behaviors. NMR shows WKY assembles through π–π stacking among tryptophan, forming a hydrophobic, electron-rich core, while WYK forms a hydrogen-bonded polar network via lysine, yielding a more electron-poor environment. WKY favors hydrophobic molecules, whereas WYK better stabilizes polar ones. At high concentrations, both form dynamic soluble aggregates and undergo liquid–liquid phase separation upon drying, rigidifying into solid microstructures. These assemblies were used to encapsulate and protect VB_2. Combining molecular dynamics, spectroscopy, LC–MS, circular dichroism, and NMR, we found that the peptides form hydrophobic cages: aromatic residues drive stacking and partitioning, while lysine enhances solubility. VB_2 coated with either peptide retained full stability under UV and visible light in the dry state and showed a ten-fold stability increase in solution. This simple platform offers broad potential for stabilizing light-sensitive molecules in pharmaceutical and nutraceutical applications.

Figure 1: Tripeptide Structure

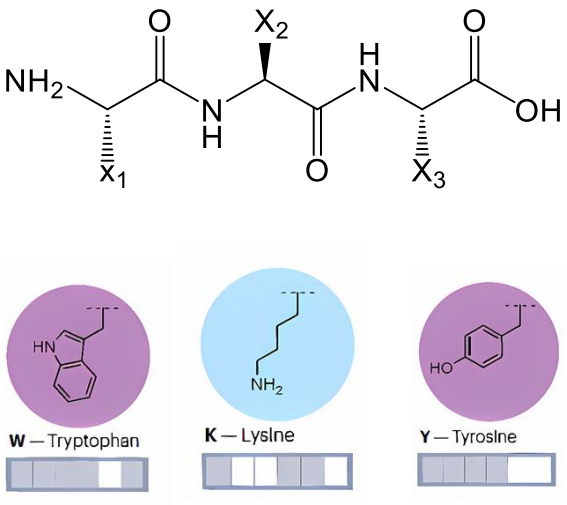
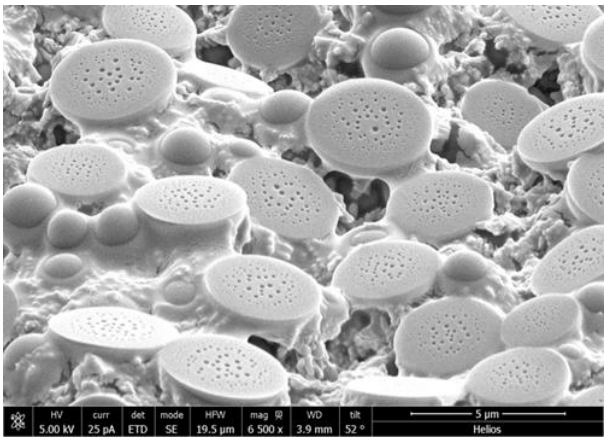


Figure 2: SEM image showing a mixture of porous spheres and half-dome particles at the interface and also showing surface pores.



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