# Polymer Science and Engineering

**Task 1:**

Lubomirsky's review presents key developments in polymeric stationary phases for size exclusion chromatography (SEC), also known as gel permeation chromatography (GPC). The efficiency of the SEC depends significantly on the stationary phase, which is responsible for separating macromolecules by size. The review categorizes stationary phases into fully porous polymer particles and monolithic columns, highlighting how design elements such as pore size, particle size, and surface chemistry affect separation performance.

Polymeric stationary phases, especially those based on polystyrene-divinylbenzene or methacrylate compositions, are widely used due to their chemical versatility and mechanical stability. These materials are prepared using suspension polymerization, allowing control over pore structure and scaling for commercial production. The authors also discuss limitations in current column technologies, particularly with very high molar mass analytes. Sub-2 µm particles, while offering high resolution, may cause sample degradation or particle breakage under high pressure. As a result, monolithic columns are emerging as a potential alternative due to their high permeability and reduced backpressure, although further refinement is needed.

The review illustrates the central role of stationary phase selection in accurate GPC/SEC analysis across a range of polymeric and biomolecular systems. For instance, wide-pore monoliths could improve the resolution for large biopolymers and extracellular vesicles. In conclusion, polymeric stationary phases enable precise size-based separation when optimized for analyte type, pressure resistance, and compatibility with mobile phases.

**Task 2:**

Tipduangta developed electrospun nanofiber mats using cellulose acetate (CA), polyvinylpyrrolidone (PVP), and caffeine for under-eye cosmetic application. By varying the CA: PVP ratio (7:3, 1:1, 3:7) and caffeine content (5–12.5% w/w), they optimized fibers for flexibility, uniformity, and rapid drug release. The best-performing formulation (CA: PVP 7:3) yielded smooth, flexible fibers (~500 nm diameter) with favorable mechanical and skin-contact properties. The goal was to produce fast-acting yet safe caffeine delivery systems using biodegradable, skin-compatible polymers.

**ATR-FTIR Analysis (Section 3.2.2):**

ATR-FTIR spectra confirmed the presence of both polymers without any chemical modification during electrospinning. Key peaks observed include ~1735 cm⁻¹ for C=O stretching (acetate ester in CA), ~1650 cm⁻¹ for PVP’s carbonyl group, and ~1360 cm⁻¹ for –CH₃ bending. Additional peaks at ~1230 and ~1040 cm⁻¹ corresponded to C–O and C–O–C stretching in cellulose. No new peaks appeared, indicating no covalent bonding, but slight shifts suggest hydrogen bonding among CA, PVP, and caffeine, confirming successful molecular dispersion.

**DSC Analysis (Section 3.2.3):**

DSC thermograms showed a single glass transition temperature (Tg) without distinct melting peaks, indicating an amorphous polymer matrix. Tg ranged around 160–190 °C, depending on composition, which aligns with known values for CA and PVP. No caffeine melting was observed, confirming it remained amorphous. These Tg values are consistent with polymer behavior and suggest partial miscibility. Minor Tg shifts support interactions among the components. Overall, the authors’ thermal data are valid and confirm the system’s physical stability.