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Green Solvents in Chromatographic Techniques

Miss. Komal Shashikant Desai

Lecturer

Hirwal Education Trust's College of Science (Computer Science and Information Technology) Mahad, Raigad ksdesai2307@gmail.com

Abstract: Chromatography is used extensively in various industries including, pharmaceuticals, environmental monitoring, food security and chemical construction. However, traditional chromatographic techniques are highly dependent on organic solvents which are often unstable, toxic, non-renewable and environmentally dangerous. Especially in relation to solvent selection, changes in green chemistry, permanent practices and regulatory requirements have been intensified with global care. Green solvents, such as deep eutectic solvents (DESs), supercritical fluid (SCF), ionic fluid (IL_s), and bio-based solvents are environmentally safe options that follow the principles of green chemistry. These solvents are characterised by properties such as low instability, high thermal and chemical stability, biodegradability and minimal toxicity. Their adoption in chromatographic methods not only reduces environment and health risks associated with traditional solvents, but also contributes to improving analytical efficiency and cost-efficiency. This paper presents a comprehensive review of the current landscape of green solvents in chromatographic techniques. It discovers the physical chemical properties, applications and comparable performance of various green solvents in liquid chromatography (LC), gas chromatography (GC), supercritical fluid chromatography (SFC), and other chromatographic formats. It also highlights recent innovations, major industrial and academic applications and regulatory ideas. While the integration of green solvents presents several advantages in which the consumption of the solvent is low, increased security, and compliance with environmental standards existing instrumentation, compatibility with limited solubility range, and with high initial costs are still needed to be addressed. Overall, paper underscores the transformative ability of green solvents in achieving permanent analytical practices and outlines strategic directions for future research and industrial implementation.

Keywords: Green solvents, Chromatography, Low toxicity solvents, Solvent waste minimization, Biodegradability

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