# Eco-Friendly TLC of Ciprofloxacin Using Mixed Hydrotropic Solvent Systems

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***Abstract*—This study explores the use of mixture of hydrotropic blends as green alternatives to organic solvents for the Thin Layer Chromatography (TLC) of ciprofloxacin, a common broad-spectrum antibiotic with low solubility profile. Sodium benzoate, Urea and sodium salicylate were employed as hydrotropes in the ratio of 1:2:1 to substitute the organic solvents as the mobile phase. The Rf values obtained were compared across the different systems, the Rf value for organic and hydrotropic blends were 0.61 ± 0.02 and 0.63 ± 0.03 respectively, highlighting the potential of hydrotropes in future chromatographic applications. This approach aligns with green chemistry principles by reducing the reliance on hazardous organic solvents.**

***Keywords*—Ciprofloxacin, Mixed Hydrotropy, Sodium Benzoate, Sodium Salicylate, Thin Layer Chromatography, Green Chemistry**

## I. INTRODUCTION

Ciprofloxacin is a broad-spectrum fluoroquinolone antibiotic widely used in pharmaceutical formulations due to its wide range applications in treatment of many varieties of disease [1]. Traditional methods used for analyzing ciprofloxacin like TLC, HPLC involve organic solvents that are toxic and leave behind toxic residues which are environmentally harmful [2]. With rise in the global production of pharmaceuticals, there is also rise in the amount of solvent waste generated. This calls for an urgent need for a safer alternative to reduce the negative environmental impact [3]. Green chemistry promotes the use of safer, more sustainable alternatives in chemical processes [4].

The choice of mobile phase in thin layer chromatography (TLC) is crucial for achieving effective separation of compounds. While organic solvents have traditionally been used, hydropic blends are emerging as a viable alternative that offers several benefits [5]. Hydrotropic blends typically show lower toxicity and reduced health risks compared to conventional organic solvents. Hydrotropic solubilization also avoids the residual toxicity, volatility, and pollution associated with organic solvents, making it a safer and environmentally friendly alternative [6].

Mixed Hydrotropic systems with blend of sodium benzoate, urea, and sodium salicylate have emerged as promising green agents for enhancing the solubility as well as a ecofriendly mobile component in TLC [7]. These compounds enhance the solubility of poorly soluble drugs and may serve as safer alternatives to organic mobile phase components in TLC [8].

In present research study the applicability of Hydrotropic agents as alternative mobile phase for TLC estimation of ciprofloxacin is discussed.

## II. MATERIAL AND METHODOLOGY

*A. Chemical requirements-*

- Ciprofloxacin pure sample- API
- Hydrotropes- Sodium benzoate, Sodium salicylate and Urea.
- Organic solvents- Chloroform, methanol and 25% ammonia.
- Distilled water

*B.* Procedure:

1. *Preparation of hydrotropic blend-* A hydrotropic solution was prepared by dissolving sodium benzoate, urea, and sodium salicylate in distilled water at a molar ratio of 1:2:1, respectively, to achieve a total concentration of 30% w/v. The solution was stirred continuously until complete dissolution of the solutes was achieved.

2. *TLC Procedure*

1. Preparation of TLC Plates: The Silica gel coated plates were used for the study and were then activated in hot air oven at temperature of 110°C for 30 minutes.
2. Sample Application: A standard solution of ciprofloxacin (1 mg/mL) was prepared, and aliquots were applied to the activated TLC plates using a capillary tube. Care was taken to maintain consistent spot size and uniform spacing between applications.
3. Development: The plates were developed in a TLC chamber which was pre-saturated with the hydrotropic blend of sodium benzoate, urea and sodium salicylate in 1:2:1 ratio. For comparative study, separate development was conducted using the traditional organic solvents; chloroform–methanol–25% ammonia 7:3:1 as the mobile phase.
4. Detection: The plates were air-dried at room temperature. The spots corresponding to ciprofloxacin were detected under UV light at 254 nm.
5. The Rf Values for both systems using organic and hydrotropic blend respectively as mobile phase were calculated. The retention factor (Rf) values were calculated using the formula:

Rf = (Distance traveled by the compound) / (Distance traveled by the solvent front)

## III. RESULTS AND DISCUSSION

The Rf values for ciprofloxacin using hydrotropic blend of sodium benzoate, urea and sodium salicylate were determined and compared with that of traditional mobile phase containing chloroform–methanol–25% ammonia under UV chamber.

| Mobile Phase | Rf Value (± SD) |
|---|---|
| chloroform–methanol–25% ammonia | 0.61 ± 0.02 |
| Hydrotropic blend (1:2:1) | 0.63 ± 0.03 |

Table I: Retention Factor (Rf) of Ciprofloxacin in Different Mobile Phases

The hydrotropic blend used in this study provided comparable and slightly better Rf value to the traditional mobile phase used in TLC of ciprofloxacin. The results indicate that hydrotropic systems can be used as safer and effective alternatives to toxic organic solvents as mobile phase in TLC. The Hydrotropic agents have significant potential for expansion beyond the analysis of ciprofloxacin, encouraging further research into its application for a broader range of pharmaceuticals. By optimizing hydrotropic solvent systems, researchers can increase the versatility of these methods, making them suitable for a wider array of green chromatographic application. Future studies could explore the reproducibility and scope of these systems for other APIs.

## IV. CONCLUSION

This research study highlights the promising potential role hydrotropic blend can play as alternatives to organic solvents in TLC. The hydrotropic system of sodium benzoate urea and sodium salicylate produced an Rf value of 0.63 ± 0.03, nearly identical to the 0.61 ± 0.02 observed with the conventional chloroform–methanol–ammonia mixture, demonstrating that using hydrotropic solvents does not compromise chromatographic performance.

Beyond analytical efficacy, the use of hydrotropes supports safer lab environments and also reduces the negative environmental footprint associated with organic solvent use. The promising results of this study open the door to broader applications—particularly in the analysis of other poorly soluble drugs—offering a pathway toward more responsible and greener quality control in pharmaceutical development.

In conclusion, the successful use of hydrotropic agents in TLC signifies a step forward in eco-friendly analytical methods. Future studies should focus on refining hydrotropic formulations and expanding their use across different drug classes to establish them as standard alternatives in sustainable pharmaceutical analysis.

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