# Development of Polymeric Organogels for the Removal of Toxic Pollutants from Water


## ABSTRACT

Organogels are a type of gel that contain organic solvents embedded within a three-dimensional network formed by the interaction between solvent and gelator molecules. This interaction prevents the solvent from flowing and provides flexibility to the gel. Holding significance due to their easy method of preparation, cost effective nature of materials, they can retain large quantities of the solvent medium while performing absorption and release of substances with response to various external stimuli factors considering the usage of high molecular and low molecular weight gelators. In addition to being used in drug delivery and as sensors with responsiveness and conductivity, organogels can also be used to retort various environmental issues. For example, they can be used to tackle the disposal of solvents into aquatic bodies from chemical industrial sites, the spillage of oils and organic solvents in marine bodies during transportation, the release of toxic dye molecules from textile and paper industries, and the disposal of untreated wastes and metal ions from sewage and mining industries. Furthermore, industrial effluents from paint manufacturers, along with the open disposal of pharmaceutical waste and the use of agricultural fertilizers and pesticides, contribute to water pollution during run-off. These pollutants are highly toxic and carcinogenic, and their presence of aromatic rings and harmful amines makes them highly mutagenic to certain aquatic species.

To address these environmental concerns related to water, the use of organogels, which are gels embedded with organic solvents, has proven to be an effective method for water treatment. These gels are easy to prepare and are not affected by moisture, allowing them to form stable gels that can be used for water treatment purposes. The present thesis focuses on synthesizing and characterizing polymeric organogels and exploring their potential applications in solvent absorption, as well as the adsorption of toxic dyes and metal ions. Polyvinyl alcohol, a biodegradable polymer, has been selected as the primary polymer for constructing all the prepared organogels. Detailed investigations into the formation of various organogels and their respective applications in addressing environmental concerns have been conducted.

Inspired by the preceding discourse, the present work addresses the development of organogels involving widely used polymers as polyvinyl alcohol, polyaniline employing the polymeric matrix mechanism. Along with the synthesis, characterization, and evaluation of the formed organogel were equally focused. The research conducted in this thesis has been organized into five chapters. A concise overview of the content covered in each chapter is provided below.

**Chapter 1: Introduction**

This chapter of the thesis outlines the research framework on organogels where the discussion is focused on the significance and background of the research works carried out. The types of organogels, their properties, and the factors that contribute to their formation are also reviewed in this chapter. Additionally, the mechanistic routes to synthesizing organogels are discussed. The chapter also highlights the diverse applications of organogels, including their use in environmental remediation. The objectives and plan of the present investigation are summarised in this chapter.

**Chapter 2: Removal of organic solvents through a fatty acid grafted polyvinyl alcohol based organogel**

This chapter describes the synthesis of an organogel system prepared from polyvinyl alcohol (PVA) and stearic acid (SA). The evaluation of their solvent absorbing property was thoroughly discussed (Figure 1). The prepared organogel was characterized by FT-IR, SEM, P-XRD, thermal and rheological analysis. Swelling kinetics of the solvent absorbed organogel followed by desorption kinetics were also studied.

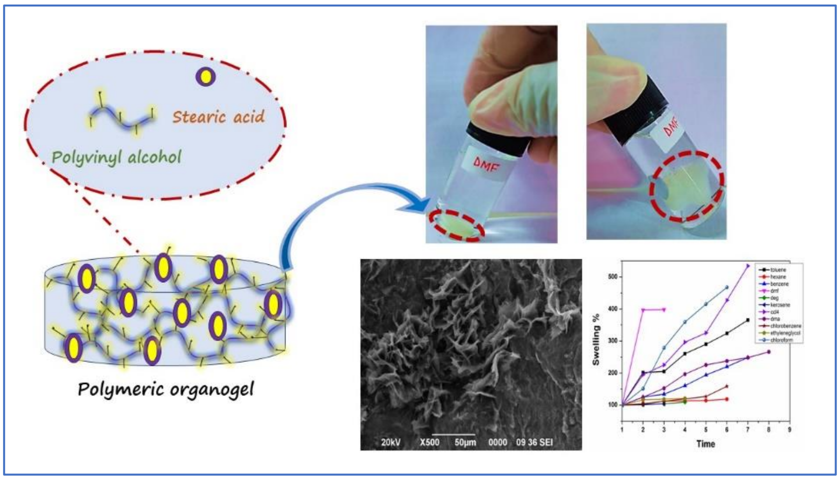


**Figure1.** Formation of polymeric organogel and its application in solvent absorption

**Chapter 3 (Section A): Grafted polymeric organogel as an effective medium for removal of cationic dyes and organic pollutants from contaminated water**

This section presents a discussion on the synthesis of a series of organogels that possess the capacity for solvent absorption. Modified from the previously prepared system, the organogel was synthesized by further addition of monomer acrylamidomethylpropane sulfonic acid and methylenebisacrylamide as crosslinker. The resulting gel exhibited a remarkable ability to absorb up to 915% of organic solvents. Additionally, due to the presence of active sites, the organogel was capable of adsorbing cationic dyes from contaminated sources (Figure 2). A comprehensive investigation into the influence of various parameters on dye adsorption was conducted, including an analysis of kinetics and isothermal plots.

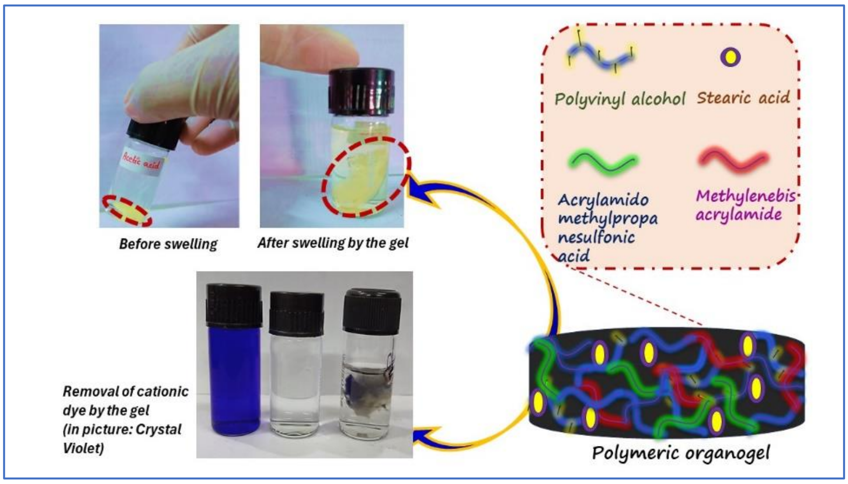


**Figure2.** Polymeric organogel and its application dye adsorption and solvent absorption

**Chapter 3 (Section B): Polymeric organogel as an effective approach for removal of heavy metal ions from water through adsorption stratagem**

This section describes the application of organogel in the adsorption of heavy metal ions from water. The organogel was characterized using SEM and FT-IR techniques, while the presence of metal ions was detected using AAS, SEM-EDX, and XPS analyses. The highest observed removal rate was found to be 79% (Figure 3). Additionally, an adsorption study was conducted on several transition metals. The kinetics and mass transfer plots were analyzed to elucidate the adsorption process.

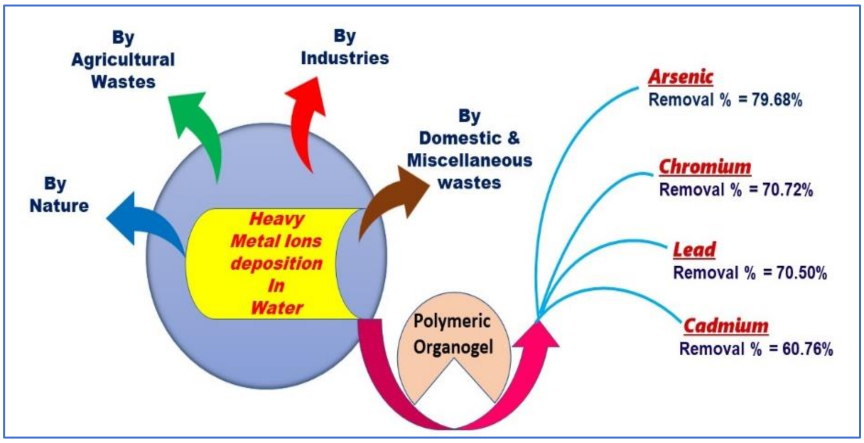


**Figure3.** Polymeric organogel as an effective adsorbent towards metal adsorption

**Chapter 4: Aluminum montmorillonite/polyaniline hybrid composite-based PVA organogel for removal of carcinogenic chlorophenols and congo red dye from contaminated water**

This chapter highlights the synthesis of hybrid organogels, specifically the in-situ formation of polyaniline between the sheets of montmorillonite clay to create nanocomposites. Different weight percentages of these nanocomposites were then reacted with polyvinyl alcohol to produce various sets of hybrid organogels. The resulting organogels exhibited rapid absorption of liquid phenols, with the ability to swell up to 20 times their own weight (Figure 4). Additionally, selective adsorption of anionic dyes was conducted using the prepared organogel. The impact of various parameters on dye adsorption was evaluated through simultaneous isothermal and kinetic studies.

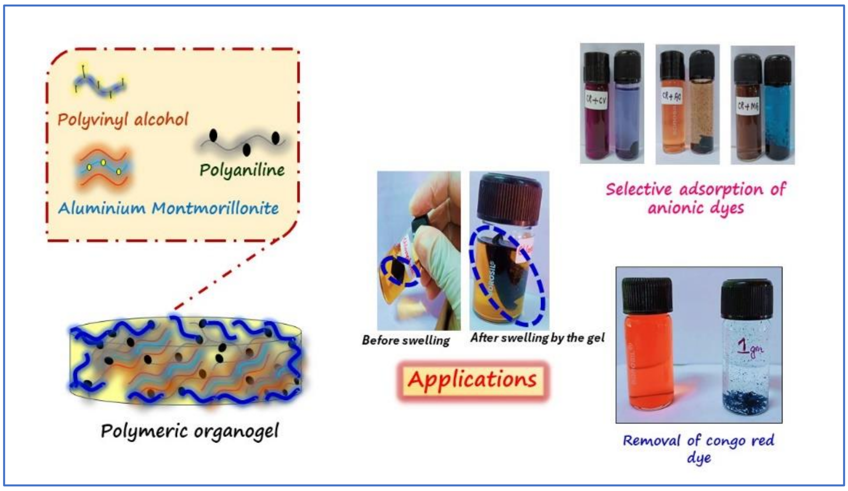


**Figure4.** Polymeric organogel and its application towards selective dye adsorption and phenol absorption

## Chapter 5: Conclusion and Future scopes

The concluding chapter of the thesis includes a comprehensive summary, key findings, and future prospects of the present investigation. The primary objective of the conducted research is to explore the environmental applications of organogel in treating contaminated water, particularly focusing on its capacity for absorbing organic solvents, adsorbing metal ions, and dye molecules. These gels, in turn, present exciting possibilities for the development of high-performable organogels with a diverse range of applications in the future.