Solubility of the Waste Thermacol in Organic Solvent Systems to form Value Added Material

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Abstract **- The main objective of this study was to investigate the ability of the Thermocol (Polystyrene) to get solubilized in the various organic solvents and to obtain a new strategy to lower its accumulation in landfill as well as to formulate a by-product of the mixture. The preliminary solubility of the thermocol in the various solvents has been confirmed by visual observation by noticing the change in the transparent solvent after addition of small pieces of thermocol into the solvents. The thermocol pieces were found to be soluble in 30 ml of petrol, acetone, and their combinations in the ratio of Petrol: Acetone (10:20) and Acetone: Ethanol (20:10). The solid thermocol piece was converted into the coagulated mass of sticky nature in the organic solvents to form useful product excellent for several applications. Overall, the organic solvent such as petrol, acetone and ethanol may be productive to apply in dissolving the thermocol type of plastic lowering the theme issue of thermocol degradation. The formulated soluble thermocol may have various applications. Therefore, the present research work results are useful to minimize the harmful effects on environment as well as human health caused by the thermocol. In addition, the soluble product formed could be used in different areas such as pasting, glue, in roads, construction, factories, ceiling, furniture, insulations, craft, air conditioning, sound proofing, false ceiling and pipe insulation. This by-product obtained is a very strong and useful adhesive as per its consistency. It can be the constructive material in future which is called as adhesive. Moreover, this by-product can reduce the challenges and expenditure by using as a binding material. The indirect benefits include reusing the waste thermocol and the fuel required to burn the waste thermocol and to control the environmental pollution up to certain extent.**

Index Terms **- Acetone, Ethanol, Plastic, Petrol, solubility test and Thermocol.**

I.INTRODUCTION

Plastic is one of the greatest innovations of modern life commonly used to describe a wide range of synthetic materials that are used in huge and growing range of applications. Polymerisation and polycondensation are the two main processes require specific catalysts to produce plastic (Suman and Smita. 2013; Aggarwal et al., 2020). In a polymerisation reactor, monomers such as ethylene and propylene are linked together to form long polymer chains. Each polymer has its own properties, structure and size depending on the various types of basic monomers used. The plastic has been various types based on its composition (polyamide, polycarbonate, polyethylene terephthalate, polypropylene, polystyrene, polyurethane and polyurethane) and its uses are designated in table 1 (Suman and Smita. 2013).

The plastic polystyrene (PS) is thermoplastic called as thermocol which is a synthetic aromatic hydrocarbon polymer made from the monomer known as styrene (Aggarwal et al., 2020). Polystyrene – C8H8 –is a synthetic, thermoplastic, petroleum product and its structure is shown in figure 1. It is manufactured from a liquid hydrocarbon that is commercially manufactured from petroleum. Polystyrene is obtained by the polymerization of styrene or phenylethene.

Table 1. Shows the types of plastic and uses

Sr. no	Plastics names	Uses
1.	Polyamide (nylon)	Women's stockings, gears, car parts, toothbrush bristles
2.	Polycarbonate	Bulletproof glass, compact discs, DVDs
3.	Polyethylene	Tubes, bottles, shopping bags, milk jugs, body armour
4.	Polyethylene terephthalate	PET used for bottles
5.	Polypropylene	food containers, chairs
6.	Polystyrene	CD cases, plastic cups, plastic forks and knives, thermocol

7.	Polyurethane	Rubber, foam, shiny coatings on wood and tiles
8.	Polyurethane (PVC)	Pipes (chemicals can make PVC softer for toys and cushions)
9.	Polyester	CD cases, plastic forks and knives, thermocol

Polystyrene – C8H8 –is a synthetic, thermoplastic, petroleum product and its structure is shown in figure 1. It is manufactured from a liquid hydrocarbon that is commercially manufactured from petroleum. Polystyrene is obtained by the polymerization of styrene or phenylethene. The chemical properties of styrene are identical to polyethene, which is the most common plastic (Suman and Smita. 2013). Polystyrene can be solid or foamed and it is the fourth biggest polymer produced in the world after polyethylene, polyvinyl chloride and polypropylene (Farooqi. 2016; Aggarwal et al., 2020).

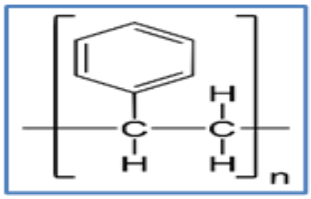

Figure 1. Shows the structure of the synthetic, thermoplastic polystyrene (thermocol is a synthetic substance created from polystyrene), (Wunsch. 2000).

1.1 Thermocol

The thermocol is a synthetic substance created from polystyrene and is another name for Polystyrene made from the synthetic aromatic (benzene derivative) polymer. It is a monomer styrene (a monomer is a molecule that may bind chemically to other molecules to form a polymer (Sharma. 2017). Thermocol is non-hydroscopic means that it does not absorb water easily which makes it useful in different ways. It is commonly used in food packaging industry as a foam container includes drink cups, food trays and clamshell containers. It is also use as Shock absorbing and as the cushioning material in EPS packaging to ship electronics, furniture and fragile items like vaccines and medicines in medical coolers and even fish. This rigid lightweight foam can be moulded into any shape and offers excellent protection and insulation. Thermocol also use for craft, air conditioning, sound proofing, false ceiling, pipe insulation, etc.

1.2 Toxicity

The plastic and its sub type such as the thermocol are categories as useful though there are some drawbacks which proved to be harmful for the soil, plants, animals and ecosystem. The thermocol may remain in soil for long time and interact to change the soil chemistry by increasing water evaporation, drying out the soil, and could accumulate in soil. This thermocol is toxic to soil, and its micro form effects in terrestrial ecosystems, on soil physical properties and which impact on plant growth negatively. Thermocol and its derivative products have the tendency of easily breaking into small pieces. These when consume by animals as a food from landfills could choke animals. Besides, thermocol containing the styrene and benzene are suspected to possess the carcinogens and neurotoxins which may absorbed into bloodstream and tissues during partial breakdown by hot foods and liquids and it is hazardous to humans. Styrene also appears to mimic oestrogens in the body, disrupting normal hormone functions, thyroid problems, menstrual irregularities, hormone-related problems, breast cancer and prostate cancer (Sathyanarayana et al., 2008; Thompson et al., 2009). Chronic exposure to high levels of styrene can cause liver damage and nerve tissue damage. The EPA and the International Agency for Research on Cancer have established styrene as a possible human carcinogen. For those who are exposed regularly in the manufacture of products made with styrene, some of the acute health effects experienced include irritation of the skin, eyes, upper respiratory tract and gastrointestinal effects. They can get a condition called “styrene sickness”. There chronic exposure leads to effects on the nervous system includes depression, headache, fatigue, weakness, minor effects on kidney function, etc (Thompson et al., 2009; Aggarwal et al., 2020).

The plastic and its related products in the ecology has been accumulated and it’s no degradation is the major cause that has catches the attention of the many researcher for finding the solution to solubilise them or to decompose in nontoxic form. Therefore, with respect to the above-mentioned problem, in the present work the solubility of thermocol in various organic solvents has been explored to find the suitable liquid phase to dissolve thermocol and to use them in different application.

II MATERIALS AND METHODS

The materials that are required for the experimentation are purchased from the sigma scientific as petrol, acetone, ethanol, beaker, glass road, petri plate etc.

2.1 Dissolution of thermocol

The large part of the thermocol was cut into small pieces and added into the beaker containing different solvents such as petrol, acetone, ethanol and in combinations. The 30 ml of petrol and 30 ml of acetone used to dissolve thermocol individually. In addition to these 30 ml solvents in the combination of petrol: acetone (10:20) as well as ethanol: acetone (10:20) were used to dissolve the thermocol. The addition of pieces was done by constant stirring till the thermocol. The solvents used for dissolving the thermocol are shown in the figure 2. The solubility of the thermocol has been observed by naked eyes.

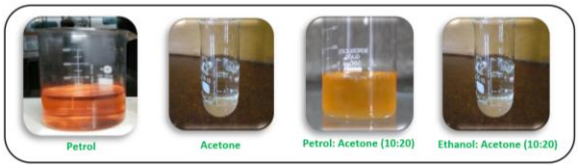

Figure 2. Shows the different solvents used for dissolving the thermocol.

III RESULTS

3.1 Formation of coagulated mass

The thermocol pieces are dissolved in the beaker and there is the formation of coagulated mass which was remained as the byproduct of thermocol. The solubility of the thermocol in the solvents and the complete reaction process is carried out at normal room temperature. The complete process of dissolution of thermocol using petrol, acetone and ethanol and observed changes in the consistency from liquid to sticky natured pulp, confirming the synthesis thermocol by product. The complete dissolution process of the thermocol in the petrol is shown in the figure 3.

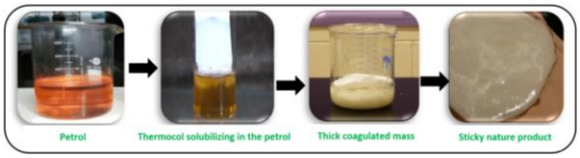

Figure 3. Displays the complete dissolution process of the thermocol in the petrol.

Similar to the petrol, other solvents have been used for the solubility test of the thermocol. The comparative solubility of the thermocol in petrol and petrol: acetone (10:20). The comparative solubility of the thermocol in 30 mL of petrol (100%) and petrol: acetone (10:20) is shown in figure 4. It was observed that the thermocol is quickly soluble in the petrol: acetone (10:20) as compare to the petrol (100%). The consistency of by product was slightly different on the basis of solvent where thermocol was dissolved.

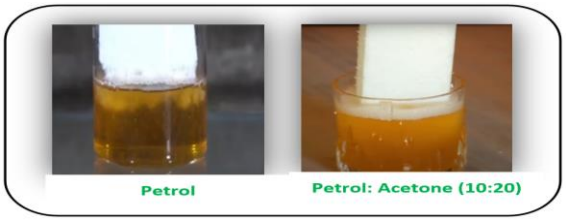

Figure 4. Shows the comparative solubility of the thermocol in 30 mL of petrol (100%) and petrol: acetone (10:20).

IV DISCUSSION

The type of plastic, thermocol degradation is the one of the important issues which is subsided in comparison to the plastic accumulation. There have been very little information and research articles that deal with the thermocol dissolution or to convert them into other nontoxic useful forms. The present study deals with the solubility of thermocol in the organic solvents in order to make them soluble or to convert them into useful form. Thus, we tested solvents system such as petrol, acetone, ethanol and in combinations of those. It was observed that thermocol get dissolved quickly into the petrol, acetone, mixture of petrol and acetone as well as ethanol and acetone which is primarily observed by the reduction in the size of thermocol sheet. The solubility method is one of the simplest methods to obtained sticky mass the final product is very less smelled. This solubility test showed a good and eco-friendly method where petrol: acetone was proven as a better solvent to dissolve the thermocol. One of the important aspects of this method is that it did not need any heat energy or other supplement to dissolve thermocol. The Aggarwal et al (2020) have used the thermocol and the petrol for formation of the adhesive in the construction work. In contrast, our work states the dissolution of thermocol for its solubility and the product formed is sticky glue-like material, which could possibly use for different application. The appearance of a white layer of glue-like structure confirmed the formation of a coagulated by-product of thermocol in the solvent. We observed

that the final dissolved sticky property of the product may be used for different application such as glue, paper craft, wood, plywood, road and construction work.

The final sticky products after dissolved thermocol in the given solvents are shown in the table 2.

Table 2. Show the nature, odour, colour of the final product formed after solubility of thermocol in different solvent system.

Solvents	Nature	Odour	Colour appearance
Petrol 30mL	Liquid with less sticky	slightly petrol fuming odour	Pale colour
Acetone 30mL	Homogeneous adhesive liquid with sticky	slightly acetone fuming odour	White colour
Petrol: Acetone 10:20mL	Homogeneous adhesive liquid with less sticky	slightly solvent mixing odour	White colour
Acetone: Ethanol 20:10mL	Adhesive liquid with more sticky	slightly acetone fuming odour	White colour

Future scope of the sticky product

To use this sticky paste for binding various materials in wooden industries, construction, metal industries, shipping industries, road construction etc., the change in the form of the thermocol will minimize the thermocol environmental. However, the toxicity of the sticky formulated paste needs to be investigated.

V CONCLUSION

Plastics and its types including the thermocol are used widely everywhere in our life and without plastic, modern civilization would indeed look very diverse. However, the long-time is required for their degradation in environment and persistence remain in the soil, water may accumulate them finally into the food web. The cancer-causing chemical contents including the styrene and benzene may causes the human health hazards. Therefore, the present study focuses on the solubility of the thermocol in solvents to make them easily degradable or to convert them into other useful materials. However, the toxic effects of the thermocol dissolved into the solvents and their formulated by product for application on human health and environment and possible consequences of health risk assessment is essential. The thermocol soluble paste obtained in the petrol: acetone, is a very strong and useful adhesive as per its consistency. It can be the constructive material in future which is called as adhesive. Moreover, this by-product can reduce the challenges and expenditure by using as a binding material. The indirect benefits include reusing the waste thermocol and the fuel required to burn the waste thermocol and to control the environmental pollution up to certain extent.

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VII CONFLICT OF INTEREST

The authors declare no conflict of interest.

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