

POLYMER DEGRADATION STUDY THROUGH VISCOSITY USING PVA AS THE MODEL COMPOUND

Submitted in partial fulfilment of the requirements for the award of

Bachelor of Science Degree in Chemistry

By

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SATHYABAMA

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(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A" by NAAC

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May 2023



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BONAFIDE CERTIFICATE

This is to certify that this project report is the bonafide work of **ANITHA C (40030002)**, **NITHYA.K (40030024)**, **HEMAVARSHINI.G (40030012)** who carried out the reports entitled "POLYMER DEGRADATION STUDY THROUGH VISCOSITY USING PVA AS THE MODEL COMPOUND" under my supervision from December 2022 to May 2023.

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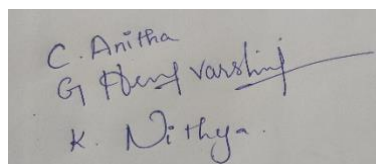
Submitted for Viva voce Examination held on

Internal Examiner

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DECLARATION

We **C.ANITHA (40030002), K.NITHYA (40030024), G.HEMAVARSHINI (40030012)** hereby declare that the **“POLYMER DEGRADATION STUDY THROUGH VISCOSITY USING PVA AS THEDEL COMPOUND”** done by me under the guidance of **Dr.S.SUPRIYA Ph.D.**, is submitted in partial fulfilment of the requirements for the award of Bachelor of Science degree in Chemistry.

A photograph of a piece of paper with three handwritten signatures in blue ink. The signatures are written one above the other: 'C. Anitha', 'G. Hemavarshini', and 'K. Nithya'. A horizontal line is drawn across the signatures.

DATE : 08.05.2023

PLACE : Chennai

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ACKNOWLEDGEMENT

We are pleased to acknowledge our sincere thanks to Board of Management of **SATHYABAMA** for their kind encouragement in doing this project for completing it successfully. I am grateful to them.

We convey our thanks to **Dr. REKHA CHAKARAVATHI, Prof.** and Dean, School of Science and Humanities and **Dr. J.KARTHIKEYAN, Head of the Department, Dept. of Chemistry** for providing us necessary support and details at the right time during the progressive reviews suggestions and constant encouragement paved way for the successful completion of my report work.

We would also like to express our sincere and deep sense of gratitude to our Project Guide **Dr. S.SUPRIYA.**, for her valuable guidance suggestions and constant encouragement paved way for the successful completion of my project work.

We wish to express our thanks to all Teaching and Non-teaching staff members of the Department of Chemistry who were helpful in many ways for the completion of the project.

ABSTRACT

Polyvinyl alcohol (PVA) is a water soluble polymer which is commonly used for various applications. The peculiar properties of PVA and its reduction in the production cost account for its increasing market penetration and end uses. Due to its enhanced usage, PVA tends to accumulate in water bodies and causes serious removal problems. Though PVA is water soluble, discarded polymer wastes in large quantities impose disposal problems and tends to accumulate in water bodies leading to blocks in water bodies due to high viscosity. The polymer would also prevent light penetration and disturbs the survival of aquatic organisms. Also, PVA can enter the bodies of the aquatic organisms and causes their destruction. Hence is important to determine the conditions under which the viscosity of PVA can be decreased for its fast removal from the water system. Experiments are carried out mimicking the environmental conditions.. Thus polymer degradation study involving reduction in viscosity is studied based on the variaion in pH, presence of nanomaterials, temperature and metal ions.

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CHAPTER-1

1.1 INTRODUCTION

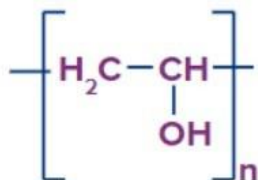
Polyvinyl alcohols (PVA) are synthetic polymers used since the early 1930s in a wide range of industrial, commercial, medical and food applications including resins, lacquers, surgical threads and food-contact applications [1] Polyvinyl alcohol (PVA) is the only vinyl polymer that can be used by bacteria as a carbon source and energy source. Under the action of bacteria and enzymes, PVA can be degraded by 75% in 46 days, so it belongs to a kind of biodegradable polymer material. PVA is a water-soluble polymer with a carbon chain as the main chain and a large number of hydroxyl groups in the side chain. It can be produced on a large scale by non-petroleum routes, with low price and good film-forming properties shows the structural formula of PVA resin. PVA film is flexible, transparent, non-toxic, non-hazardous and biocompatible; it has good mechanical properties chemical resistance, and gas barrier, and can be completely biodegradable in line with the development of green environmental protection needs.[2] *Viscosity measurements of polymer solution shows the existence of molecular interaction between the polymer and the solvents. From these measurements, the extent of interaction can also be predicted. Solvation dynamics and its experimental and theoretical studies have given rise to renewed interest in the field of research activities* [3] Polyvinyl alcohol (PVA), which is essentially made from polyvinyl acetate through hydrolysis, is easily degradable by biological organisms and in water is a solubilized crystalline structure polymer. PVA is an artificial polymer that has been used during the first half of the 20th century worldwide. It has been applied in the industrial, commercial, medical, and food sectors and has been used to produce many end products, such as lacquers, resins, surgical threads, and food packaging materials that are often in contact with food [4].



Figure 1.1 Poly Vinyl Alcohol (PVA)

1.2 Sturucture of Polyvinyl alcohol

Polyvinyl alcohol is a polymer, so it comprises small monomer units bound. The monomeric unit of polyvinyl alcohol is vinyl acetate. The polymerization of vinyl acetate results in the polymer's formation of polyvinyl alcohol. The direct polymerization of vinyl acetate is not possible. Hence, polyvinyl alcohol is prepared by the hydrolysis of polyvinyl acetate in the presence of an alcohol (mainly methanol) and an alkaline catalyst.



PVA Structure

Poly(vinyl alcohol) (PVA) is a well known synthetic polymer that is attracting renewed interest for the production of environmentally friendly plastic materials. The rather peculiar PVA properties and its gradual reduction in production cost account for its increasing market penetration and end uses. In particular four major segments of PVA consumption include: warp sizing, paper coating, adhesives, and films. "Biodegradable" disposable PVA items (mulching films, laundry bags etc.) can reach the environment without entering any integrated system of waste treatment. Therefore, the biodegradability of PVA and PVA-based systems is a fundamental instance to be ascertained. Basic properties of these materials are very much depending upon the degree of polymerization, degree of hydrolysis, distribution of hydroxyl groups, stereoregularity and crystallinity of PVA; thus also, the assessment of the relationship between biodegradability and polymer structure is of utmost importance [5].

CHAPTER-2

LITERATURE SURVEY

Tayser Sumer Gaaz, Abu Bakar Sulong [4] and his partners studied the preparation, characterization, water absorption capacity, thermal stability and flame retardant behavior of PVA-HNTs nanocomposites with special reference to filler loading. This polymer has been studied widely based on clinical and nonclinical research. PVA-HNT nanocomposites can be used in general clinical operations such as cartilage replacement or cartilage transplantation because they have the advantage of being readily available compared with cartilage transplantation. Disease transmission concerns and limited availability characterize cartilage transplantation. Moreover, PVA-HNT nanocomposites can be used in eye contact lenses, eye drops, and drug delivery systems to target tissue with abnormal growth rates. PVA and PVA-HNT nanocomposite applications due to their biocompatibility, non-toxicity, noncarcinogenicity, smoothness, and flexibility in potential applications in bone tissue engineering and drug delivery systems.

Baodong Liu, Jianhua Zhang, and Hongge GuO [6] were studied the reviews of water-resistant modification methods of polyvinyl alcohol and the application of water-resistant films and provides an outlook on the development trend of PVA water-resistant films. They achieved Globally, a “plastic ban” is under promotion, and the development of PVA film is bright. In order to expand the scope of application of PVA films, it is necessary to modify them for water resistance. The use of multiple modification methods has become a trend for single nano-fill modification, polymer co-blend modification, and chemical cross-linking modification. Because a variety of modification methods use synergistic modification, to further enhance the performance of the film, it will be enhanced; at the same time, the choice of additives will also become greater, leading to more functional films, and thus substantial increases in applicability. For the selection of additives, to integrate environmental protection, processing costs, and many other factors, for example, in the field of packaging, to consider the compatibility of blended polymers and PVA matrix, toxicity, degradability, preferably starch, gelatin, chitosan, and other biomaterials, for the choice of nanoparticles, nanocellulose, nano-chitosan, and other biomaterials can be preferentially selected.

Najla Ali Elgheryani [7] and workmates evaluated the elasticity of the samples in the case

of NaHCO_3 decreased, while in the case of NaCl it increased, as well as the Young's modulus, and for the figures of the viscosity of solutions indicate increased viscosity with increased concentration, but $\text{PVA}/\text{NaHCO}_3$ solutions have viscosities higher than that of PVA/NaCl . The treatment of viscosity data based on Huggins and Kraemers relationships allowed for evaluation of intrinsic viscosity of the PVA solutions with different concentration of NaHCO_3 and NaCl . Therefore, these results can be used to improve the properties of polymers, their solutions and segments, to benefit from them in many fields, such as industrial and medical applications and scientific studies.

CHAPTER -3

AIM AND OBJECTIVE

AIM

Aim of our project is to reduce the viscosity of polymer material which aid its fast removal from the water bodies in the presence of ZnO, Areachea powder, CuSO₄ , NaCl, pH and Temperature.

OBJECTIVE

- Viscosity analysis of PVA samples
- Study the effect of temperature on viscosity decrease of PVA
- To First prepare PVA solution containing small amount of ZnO and measure the viscosity of the solution using Ostwald viscometer.
- Measure viscosity in the presence of areachea powder.
- Determine the viscosity in the presence of metal ions such as Cu using viscometer.
- To compare the viscosity of PVA under the selected conditions with the viscosity of pure PVA.
- Finally compare all readings and find out which is the best suitable condition for the large decrease in viscosity.

CHAPTER-4

METHODS AND MATERIALS

4.1 Requirements

- Ostwald U-Tube Glass Viscometer
- Rubber Bulb
- Standard Flask - 25ml
- Pipette (10ml capacity)
- Magnetic Stirrer
- RB Flask - 250ml
- Thermometer
- Stop Watch
- Glass Beakers (100ml)
- Glass Rod

4.2 PROCEDURE

- Prepare 2.5g of PVA and add 100ml of distilled water by heating on magnetic stirrer.
- Then mix well using a glass rod and leave to dissolve for 1 hour.
- Prepare polymer solutions of 5 different concentrations (2.5,5,7.5,10,12.5) in 25ml standard flask.
- Take 0.05g of ZnO add 10ml distilled water using measuring cylinder.
- Then make 25ml mixture in standard flask
- Shake well and leave the solution for 2 days.
- introduce it in the bulb A of a viscometer.

- Suck air by using rubber suction bulb.
- When liquid comes at appropriate level in the viscometer, it is released and the time taken to cross the level is determined.

4.3 ZnO – PRECIPITATION METHOD

4.3.1 Materials

Zinc nitrate as the precursor, KOH as a precipitating agent to synthesize ZnO nanoparticles were purchased from Sigma-Aldrich.

4.3.2 Preparation

ZnO nanoparticles were synthesized by direct precipitation method using zinc nitrate and KOH as precursors. In this work, the aqueous solution (0.2 M) of zinc nitrate ($\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$) and the solution (0.4 M) of KOH were prepared with deionized water, respectively. The KOH solution was slowly added into zinc nitrate solution at room temperature under vigorous stirring, which resulted in the formation of a white suspension. The white product was centrifuged at 5000 rpm for 20 min and washed three times with distilled water, and washed with absolute alcohol at last. The obtained product was calcined at 500 °C in air atmosphere for 3 hr.

4.4 Synthesis

4.4.1 Synthesis of ZnO/Polymer Nanocomposites

ZnO and PVA were mixed in different proportions in 25ml standard flasks. Different concentrations (100, 300, 500, 700, and 1000 ppm) of the polymer were prepared from the stock polymer solution. Then, ZnO was added to the polymer solutions and determined their viscosities using Ostwald viscometer.

Similarly, to different concentrations of PVA solutions were added Arachea powder, NaCl, and CuSO_4 in order to measure the decrease in the viscosity of the polymer solution. Temperature and pH variations were also done to study their effects on viscosity reduction.

CHAPTER-5

5.1 RESULT

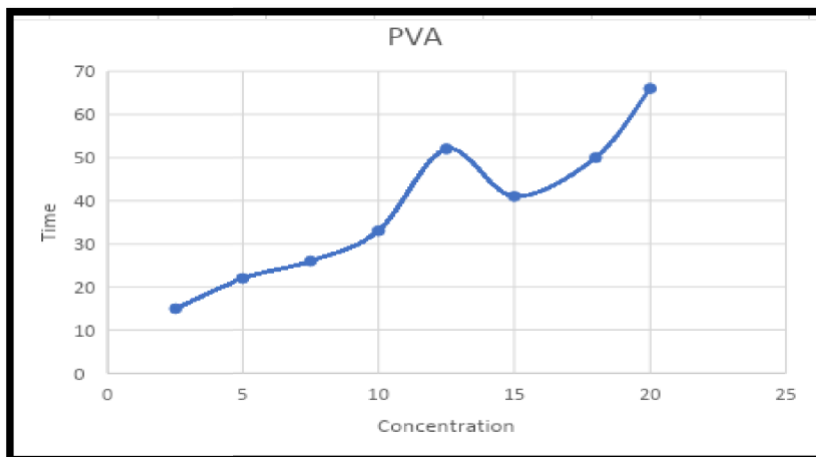


Figure 5.1 PVA

In this plot shows that rate of flow of PVA solutions at different concentrations.

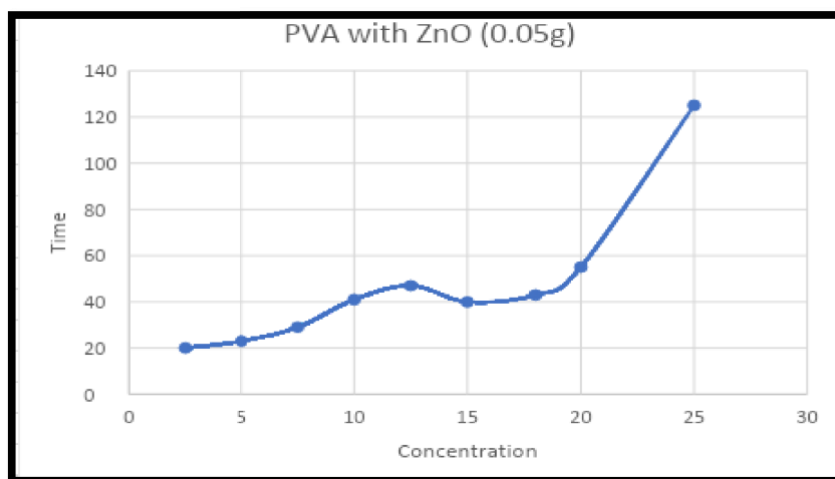


Figure 5.2 PVA with ZnO

In this graph when mixing ZnO (0.05g) with PVA , the viscosity is stablized and decreased by 20 seconds in 2.5ml concentration of PVA.

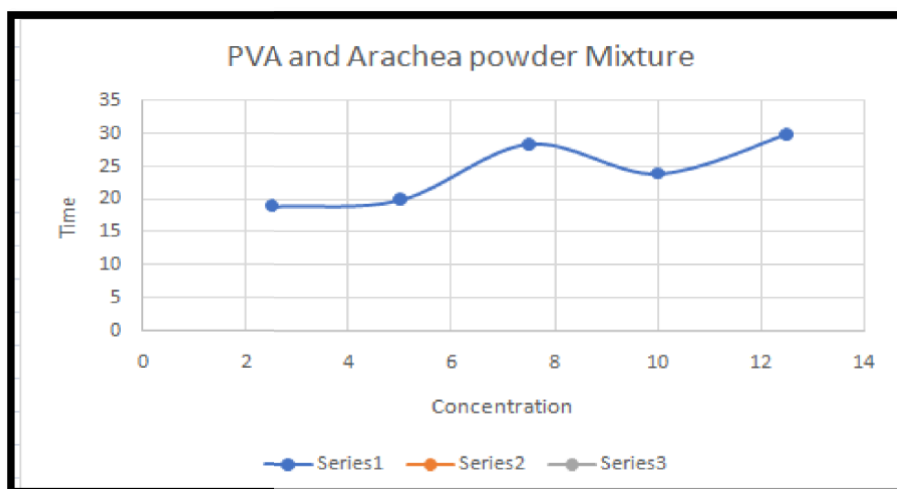


Figure 5.3 PVA and Arachea powder (0.1g) Mixture

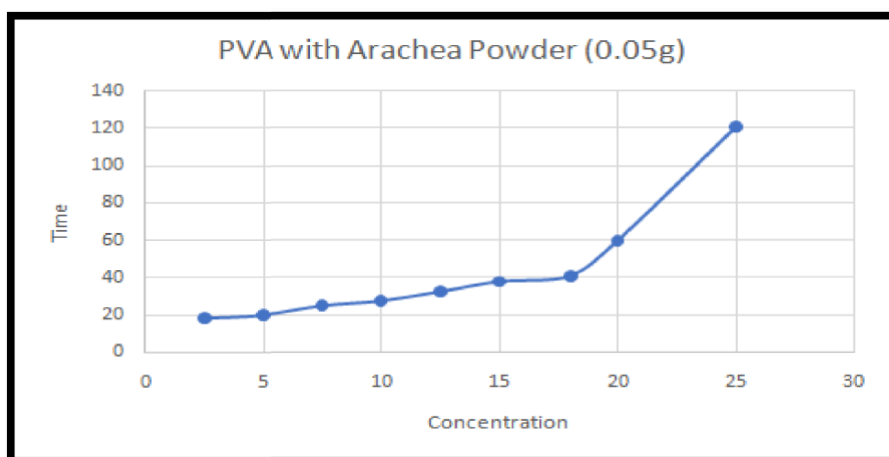


Figure 5.4 PVA with Arachea powder (0.05g)

In Fig 5.3 and 5.4 the plot shows that the presence of Arachea powder is capable of retaining the viscosity of the polymer solutions to the same extent. High viscosity is observed for the high polymer concentration, The rate of flow also increases. The rate of flow could be found that the prepared polymer pipetted out on above mentioned concentrations and add distilled water to make 25 ml in the standard flask, shake it well and leave it for 2 days to dissolve .

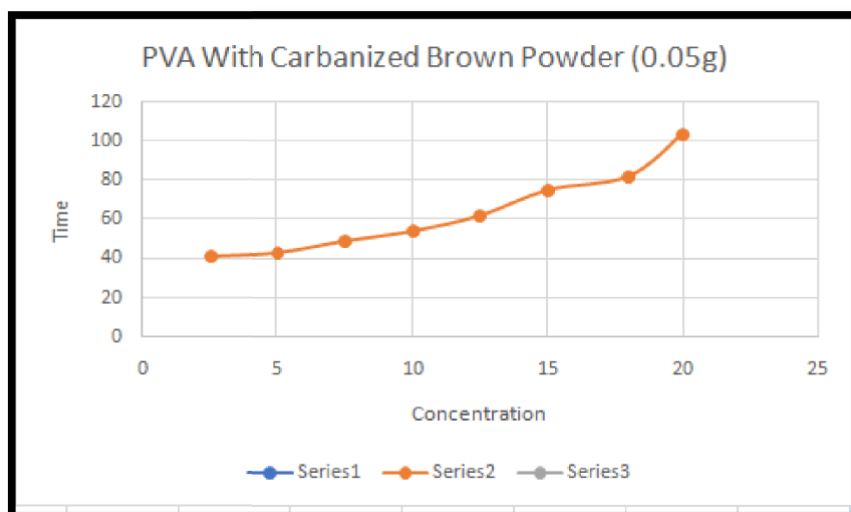


Figure 5.5 PVA with Carbonized Brown Powder (0.05g)

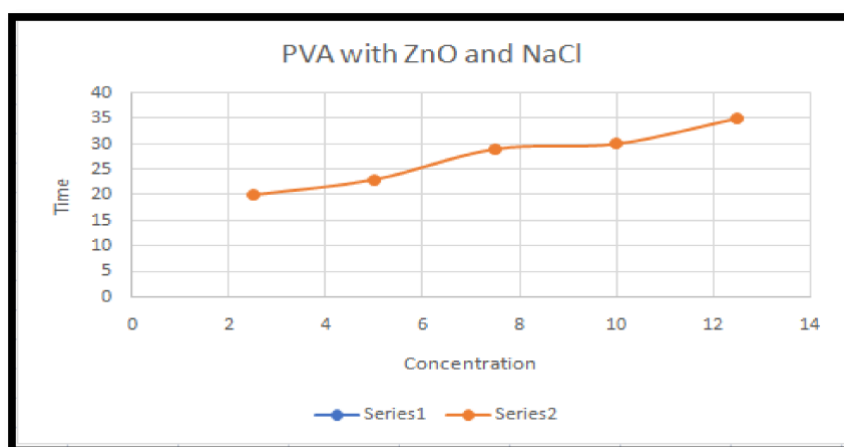


Figure 5.6 PVA with ZnO and NaCl

In the plot obtained by the addition of 0.05g of ZnO and 0.1g of NaCl to different concentrations of PVA showed a high decrease in the viscosity of the polymer solutions with high rate of flow.

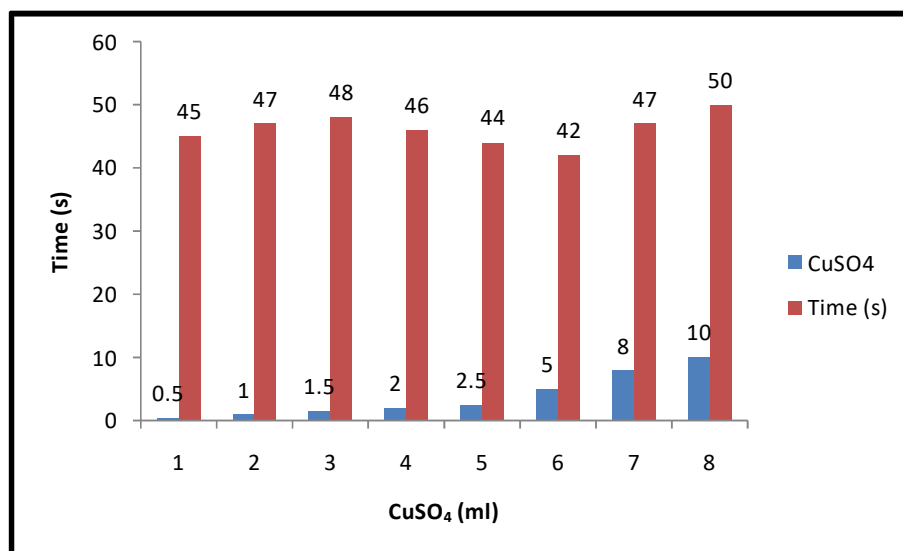


Figure 5.7 PVA , ZnO (0.05g) , NaCl (0.01g) and CuSO₄

In fig 5.7 prepared each 12.5ml of PVA solution by adding 0.05g of ZnO, 0.1g of NaCl and varying volume of CuSO₄ solution.

Concentratin	Rate of flow	Condition
12.5	62 sec	PVA+Arachea Carbonized Powder (0.05g)
12.5	52 sec	PVA Solution
12.5	42 sec	PVA + ZnO (0.05g) +NaCl (0.1g) + CuSO ₄ (5ml)
12.5	40 sec	PVA + Temperature (35°C)
12.5	38 sec	PVA + Arachea Powder (0.05g) +NaCl (0.1g)
12.5	35 sec	PVA+ZnO(0.05g) +NaCl (0.1g)
12.5	33 sec	PVA+ZnO (0.1g)
12.5	32.5 sec	PVA+ZnO (0.05g)
12.5	32.5 sec	PVA+ Arachea Powder (0.05g)
12.5	30 sec	PVA+ Arachea Powder (0.1g)
12.5	28 sec	PVA+ZnO+Temp (55°C)

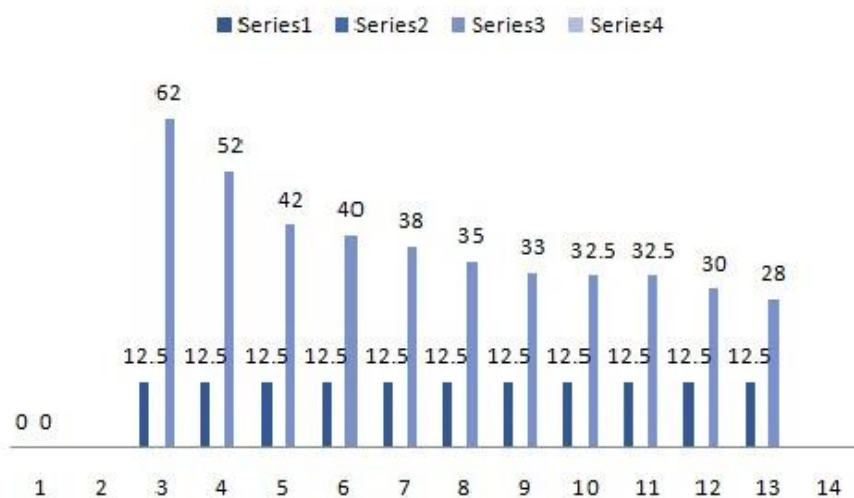


Fig 5.8 Comparison of Rate of flow of PVA under different conditions

- The plot shows a decreasing order of rate of flow.
- Prepared polymer solutions of 5 different concentrations as shown in the table.
- The lowest viscosity in this plot is corresponding to PVA along with ZnO and the temperature of 55°C.
- By heating PVA at 55°C temperature in the presence of ZnO showed the time as 28 sec.

CHAPTER-6

6.1 CONCLUSION

PVA is an artificial polymer that has been used in the medical and other fields for the last 30 years. Polyvinyl alcohol is a resin, a natural or synthetic organic compound made of non-crystalline or viscous substance. Polyvinyl alcohol widely used to strengthen textile yarn and papers, particularly to make the later more resilient to oils and grease. It is also used in the freshwater sports fishing. PVA is added to bags to that filled with oil-based or dry fishing bait and attached to the hook. Overuse of the polymer and their improper disposal results in their accumulation and pave way for environmental deterioration. Hence it is important to find solution for the safe disposal of the polymer material. Since PVA is a water soluble polymer, its decrease in viscosity can easily and safely eliminate it from the environment without getting accumulated. Therefore conditions to decrease the viscosity of the polymer is determined based on the determination of rate of flow of the polymer using Ostwald viscometer. The best prevailing condition for the high decrease in viscosity is attained using -----

REFERENCES

- [1] C.C DeMerlis, D.R Schoneker, Review of the oral toxicity of polyvinyl alcohol (PVA), Food and Chemical Toxicology, Volume 41, Issue 3, 2003, Pages 319-326, ISSN 0278-6915, [https://doi.org/10.1016/S0278-6915\(02\)002582](https://doi.org/10.1016/S0278-6915(02)002582). (<https://www.sciencedirect.com/science/article/pii/S0278691502003>).
- [2] Lin, Chia-Chang & Li ting, Lee & Hsu, Ling-Jung. (2013). Degradation of polyvinyl alcohol in aqueous solutions using UV-365 nm/S₂O₈²⁻ process. International Journal of Environmental Science and Technology. 11. 10.1007/s13762-013-0280-6.
- [3] Panda S, Mohanty G. C, Samal R. N, Roy G. S. Viscosity Studies of Polyvinyl Alcohol (PVA, Mw = 1,25,000) in Solvent Distilled Water and Aqueous Solution of Urea. Mat.Sci.Res.India;7(2)
- [4] Gaaz TS, Sulong AB, Akhtar MN, Kadhum AA, Mohamad AB, Al-Amiery AA. Properties and Applications of Polyvinyl Alcohol, Halloysite Nanotubes and Their Nanocomposites. Molecules. 2015 Dec 19;20(12):22833-47
- [5] Emo Chiellini, Andrea Corti, Roberto Solaro, Biodegradation of poly(vinyl alcohol) based blown films under different environmental conditions 11 Part of work herewith reported was presented at the 5th Scientific Workshop on Biodegradable Polymers and Plastics, Stockholm (Se) June 1998., Polymer Degradation and Stability, Volume 64, Issue 2, 1999, Pages 305-312, ISSN 0141-3910, [https://doi.org/10.1016/S0141-3910\(98\)002067](https://doi.org/10.1016/S0141-3910(98)002067). (<https://www.sciencedirect.com/science/article/pii/S0141391098002067>)
- [6] Liu, B.; Zhang, J.; Guo, H. Research Progress of Polyvinyl Alcohol Water-Resistant Film Materials. *Membranes* 2022, 12, 347.
- [7] N. Ali, "The Elasticity and viscosity of polyvinyl alcohol / sodium bicarbonate (PVA/ NaHCO₃) and polyvinyl alcohol /sodium chloride (PVA/ NaCl) samples", *International Journal of Engineering and Applied Physics*, vol. 2, no. 1, pp. 346-354, Jan. 2022.
- [8] Babaie, Ashkan & Madadkhani, S. & Stoeber, Boris. (2014). Evaporation-driven low Reynolds number vortices in a cavity. Physics of Fluids (1994-present). 26. 033102. 10.1063/1.4868546.
- [9] Vanitha, N., Kanchana, S.K., Basavaraj, R.B. and Madivalappa, S. (2023), Structural and optical properties of Polyvinyl alcohol/Zinc oxide (PVA/ZnO) nanocomposites. 30

March 2023.

[10] T.S. Soliman, M.M. Hessien, Sh.I. Elkalashy, Structural, thermal, and optical properties of polyvinyl alcohol films doped with La₂ZnO_x nanoparticles, Journal of Non-Crystalline Solids, Volume 580, 2022, 121405, ISSN 0022-3093.

[11] Yang, Haiyang & Zhu, Pingping & Peng, Chunlin & Ma, Shengli & Zhu, Qingren & Fan, Chenggao. (2001). Viscometric study of polyvinyl alcohol in NaCl/water solutions ranged from dilute to extremely dilute concentration. European Polymer Journal - EUR POLYM J. 37. 1939-1942.