Study on plasticization of thin film of polyvinyl chloride sensitized with malachite green

Bhardwaj M.K.[1*] and Awasthi S.K.[2]
Department of Physics, Government science College Jabalpur, MP, India
lachi8172@gmail.com

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Abstract

The tensile and microhardness properties of polyvinyl chloride (PVC) sensitized with malachite green in different concentration were studied. Samples are prepared by using solution cast technique. The plasticization of PVC has been reported; softening of PVC occurs with increasing concentration of dye but after a certain optimum concentration of malachite green, hardening occurs.

Keywords: Malachite green sensitized polyvinylchloride, Plasticization, hardening, solution cast technique, tensile and microhardness, intermolecular effect.

Introduction

Polymer science is among most promising branches of modern sciences, many author reported works on pure polymers. But now a day composite and sensitized polymers works are in progress because polymers are using in different fields i.e.in daily uses material like that hand gloves, foot gloves, pipe, PPE kit, water pipe etc. It is also used in different field such as energy technology, optics, sensors, medicine microelectronics etc. Different polymers have different properties i.e. there efficiency, flexibility, lightness, chemical and physical properties. Behaviour of polymers can be modified with the help of coating, doping and sensitizing. Modification of polymers as per use in various fields was practised by different researchers here we have modified character of PVC by using Malachite green.

Materials and methods

The polyvinyl chloride (PVC) and malachite green were used in the present work, while double distilled Dimethylformamide (DMF) was used as a solvent. Since DMF is not volatile like other organic solvents, because of this, solution concentration remains constant for a long time, which produces samples of equal thickness. 60 mg of PVC was dissolved in 10ml of DMF by stirring for a sufficiently long time. More concentrated solutions are not used because in that case solution becomes more viscous and the sticking effect of the sensitized solution affects the growth process which affects the reproducibility of the sample. Fresh solution contains a large number of air bubbles so it is kept in a dust free chamber for 30 minutes to allow the solution to settle down and become bubble free.

For sensitization of PVC, malachite-green is added in the solution of PVC and DMF. The sensitizer molecules diffuse into the polymer matrix. In this study, four weight percentage of PVC and malachite-green were used; PVC is sensitized with malachite-green in ratio 60:2, 60:4, 60:6, 60:8, 60:10 and 60:12 in DMF solvent. This method of sensitization was preferred because organic / inorganic dyes are known to form charge transfer states within PVC.

Pure PVC and sensitized solutions were deposited on blue start super deluxe glass plate. Before the deposition, the glass plate was thoroughly cleaned with DMF and then properly rinsed with distilled water after washing it with soap solution. Solution was prepared in a glass beaker by dissolving PVC (Pure/sensitized) in 10 ml of chemically pure DMF at 60^oC. The solution was then kept on magnetic stirrer for 4 hours to yield a consistent and clear solution. The solution thus, prepared was then poured onto a clean glass plate floating on mercury. The solvent was then allowed to evaporate in an oven at 60^oC for 6 hours which yields desired samples.

As time passes solvent which was left during preparation get evaporated and uniformly smooth and dry samples can easily be peeled from the glass surface. Thickness of samples depends upon: the concentration and temperature of the solution as well as on the time of dissolution of the substrate into the solution. The films so prepared were dried for nearly 18 hours in a dust free chamber.

Tensileand Vickers microhardness Testing: Tensile Strength is tested with Unilab Digital Tensile Strength Tester at Materials Science Laboratory, Department of Physics, Govt. Model Science College Jabalpur, India. The solid films were cut into a rectangle shape of 25mm×10mm. The thickness of the films was measured in micrometre. For tensile testing film prepared was clamped between jaws and the initial gauge length was set at 5cm. The film was dragged using a crosshead speed of 2 mm/min. During the application of stress, elongation at break (in mm) and applied force (in N) were recorded. The films that broke at the centre were used for the analysis. The tensile properties of the films were characterized by the tensile strength, percent elongation at break, breaking strength and variation of breaking load.

Vickers microhardness of the films were tested using a Vaishika Vickers Microhardness tester Type 7005 with serial no. AP-34, Ambala Cantt. 133006 India, in Bose Memorial Research Laboratory, Department of Chemistry, Govt. Model Science College, Jabalpur, (M.P.) India,Pin-482001.

Results and discussion

Figure-1 to 4 respectively shows the variation of breaking load, elongation at break, percentage elongation and breaking Strength with various Malachite Green sensitized PVC. Figures represent the behaviour of pure and various Malachite Green sensitized PVC i.e. 60:2, 60:4, 60:8, 60:10 and 60:12mg. The plot shows following trends: i. Breaking load for pure PVC is least; it increases with wt% of Malachite Green. It is maximum for 60:8mg sample; afterwards with increase in content of Malachite Green it decreases. ii. Percentage elongation increases up to 60:6mg Malachite Green sensitized PVC then decreases. iii. Breaking strength also shows identical trend it increases from 0.4N/mm to 1.1N/mm with increase in content of Malachite Green up to60:8 mg and then it decreases.

All the parameters which were studied here helps in studying the flexibility of films. Mobility of molecular chains of polymeric material is responsible for elongation produced in them. Many researchers have reported that organic and inorganic dyes behave as a plasticizer for PVC. The increase in elongation of films can be explained by the fact that Malachite Green which acts as a plasticizer, decreases the intermolecular bonds between PVC chains by filling the vacant spaces between polymer chains by replacing them with hydrogen bonds; which are formed between Malachite Green and PVC molecules. Thus rigidity of polymeric material is reduced by this disruption and reconstruction of molecular chains of polymer, in other words plasticization occurs, which promotes flexibility of polymeric film, this further allows more mobility between chains[1-3].

The possible reason behind high tensile strength for high M Green concentration is attributed to increase in concentration of hydrogen bonds between PVC and M Green; these bonds replaces intermolecular bonds in PVC addition of plasticizer i.e M Green at concentrations from 60:2 to 60:8 results in significant improvement in the tensile strength of PVC films. In pectin-based films, decrease the tensile strength with increase in the concentration of the plasticizer has been reported[4-6], here also tensile strength decreases with increase in content of Malachite Green in PVC. It may be attributed to the increase in content of plasticizer; that is concentration of M Green, which is a plasticizer for polymeric material under investigation; which reaches an optimum value, beyond which increase in weaker bonds results in decrease in tensile strength of the polymer material[7,8]. Variation in elongation and strength at break was reported elsewhere due to number of factors, such as moisture pick-up, poor dispersion and increase of interfacial defects due to debonding between polymer and substance used for changing properties of polymer under experimentation[9,10].

Variation of Vickers microhardness HV and Yield Stress with load 10,30, 50 and 100mg for pure and various ratios of malachite green are shown in Figure-5 to 8 respectively and variation of Vickers microhardness with Yield stress were shown in Figure-9 and 10. Figure-11 and 12 represent the penetration depth with sensitization. The Vickers microhardness test was taken with a load of 10, 30, 50, and 100mg. From the graph it is evident that, the Vickers micro hardness and Yield Stress both falls from pure PVC to 60:8 sensitized PVC sample. Figure-9 and 10 shows that the Vickers microhardness is proportional to Yield stress. It is very clear that any one result (i.e. Vickers microhardness or Yield stress) is sufficient to understand the variation of elastic behaviour of polymeric material. Increase in average distance D with malachite green sensitization is shown in Figure-10 and 11.

Decrease in Vickers microhardness and Yield stress and increase in penetration depth with increasing malachite green concentration is due to the plasticization effect and polymer becomes more-soft up to the optimum ratio of PVC and Malachite green i.e. 60:8.

Various studies have reported with increase in sensitizer; increase in the conduction current, decrease in activation energy occurs[11-13]. When the plasticizer content in polymer is increased, an important role in development of breakage is played by rupture of the intermolecular bonds together with mutual slippage of the segments of the macromolecules[14,15]. Hence due to rupture in intermolecular bonds polymer becomes softer. The increase in the conductivity and decreases in the activation energy with Malachite green also suggest that plasticization effect is taking place[16,17].

Conclusion

From all above studies it is clear that softness increases with increasing malachite green at optimum concentration. The cross linking between the macromolecular units affects the mechanical properties of any polymeric system, here PVC sensitized with M Green was found to be become softer with increasing content of M Green until certain concentration of M Green; afterwards plasticization effect reduces. This study presents interesting means of plasticizing PVC and those throws light on future applications.

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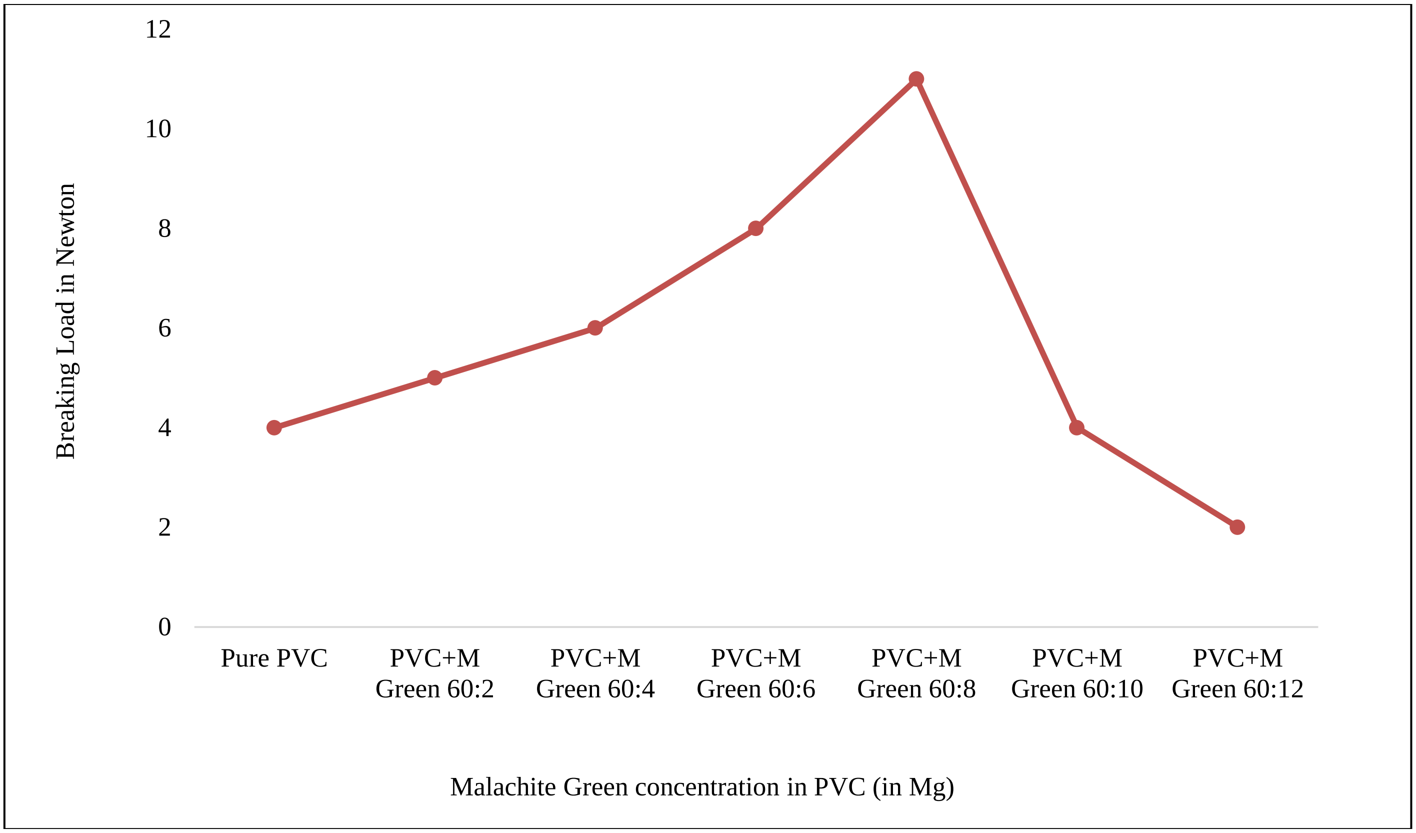

Figure-1: Variation of Breaking Load with increasing Malachite Green concentration in PVC.

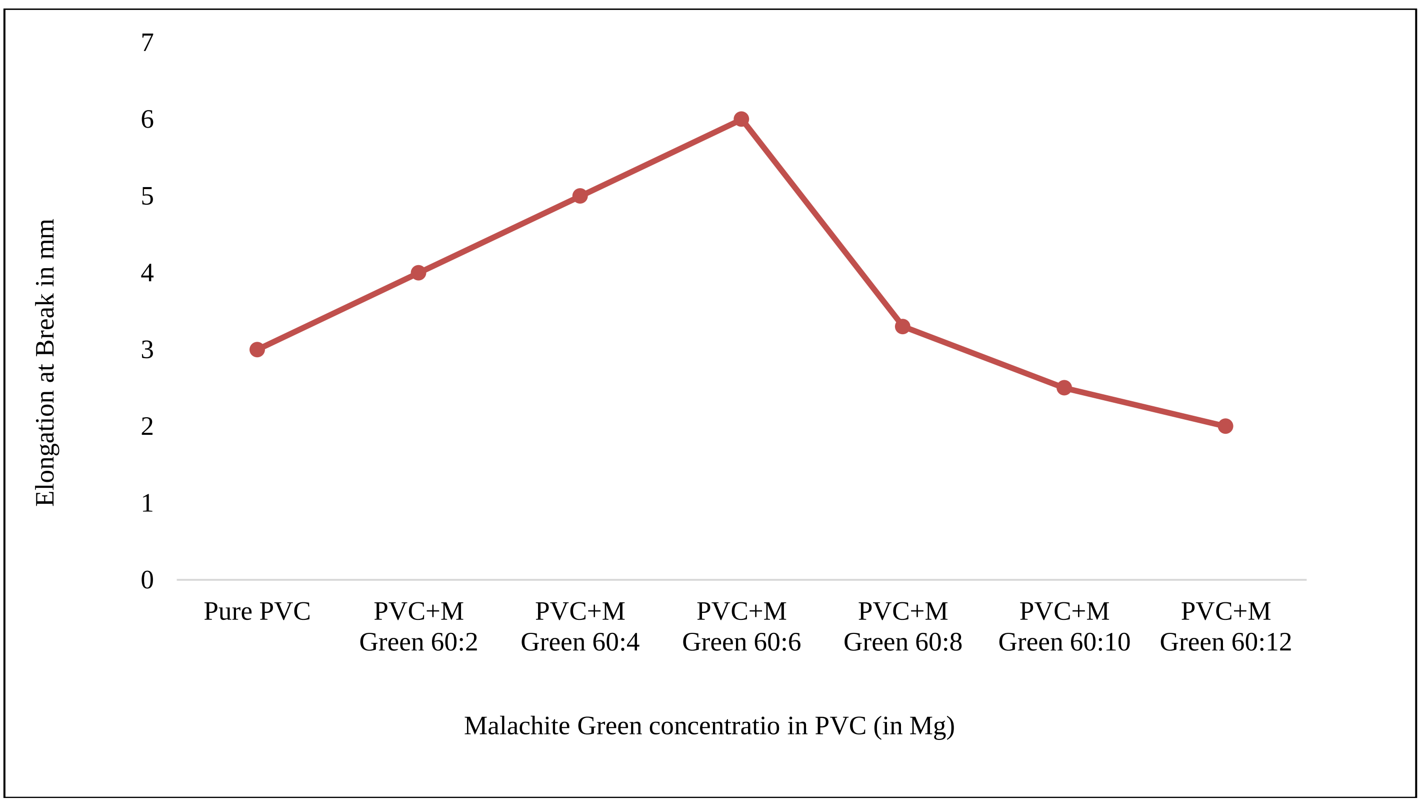

Figure-2: Variation of Elongation at break with M Green concentration in PVC.

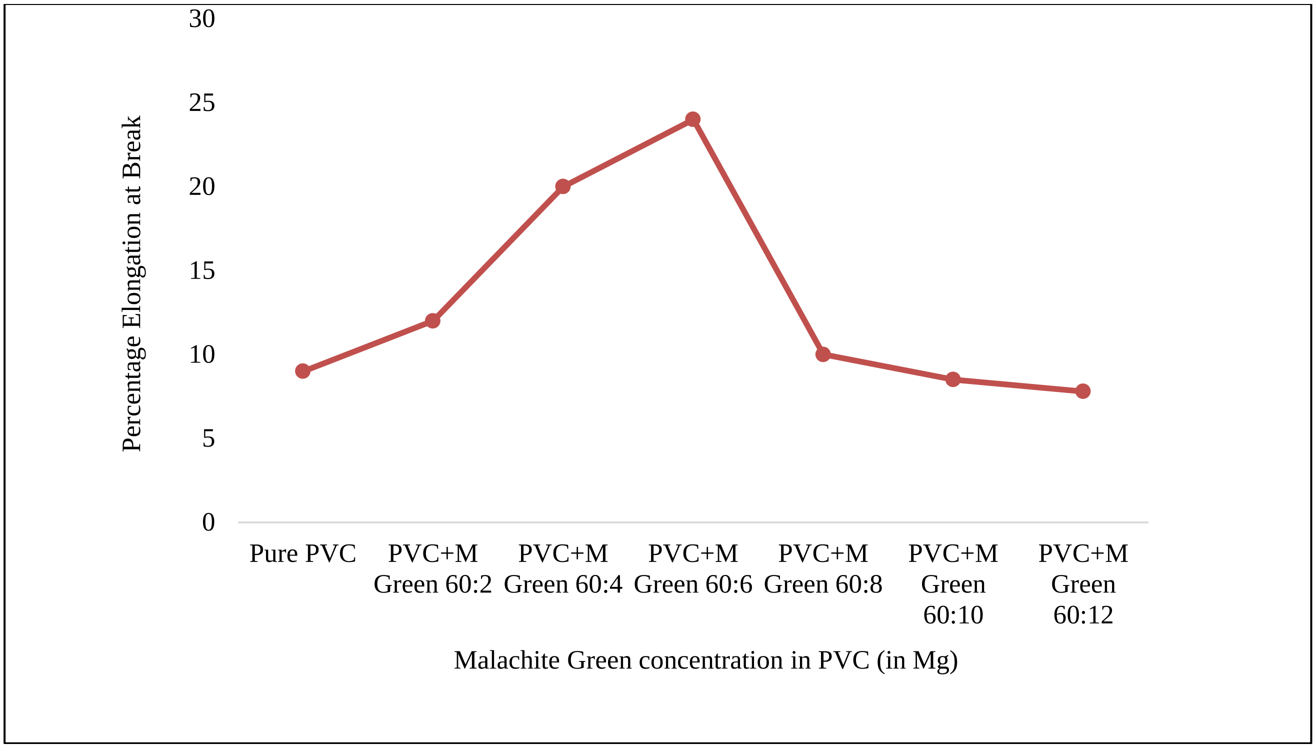

Figure-3: Variation of Percentage Elongation at break with increasing M Green concentration in PVC.

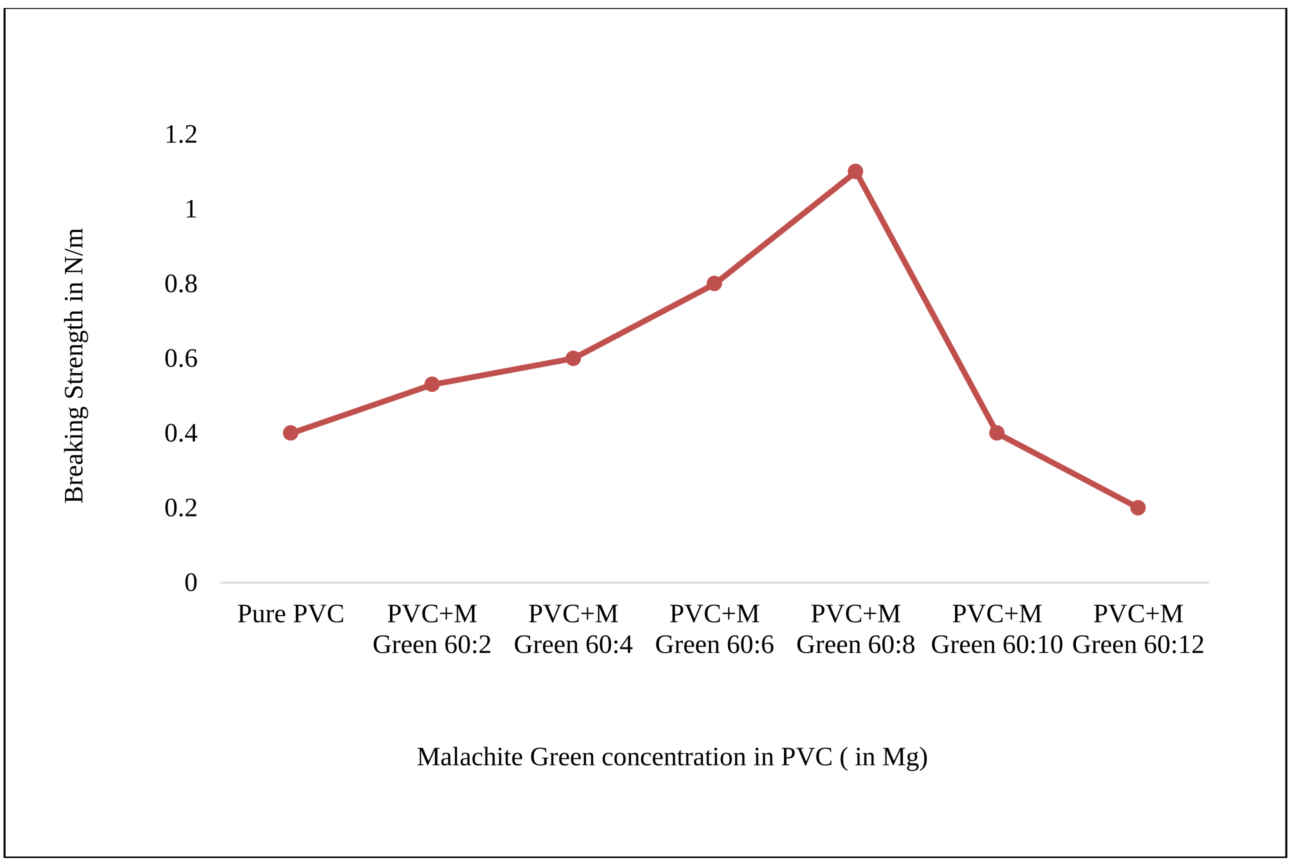

Figure-4: Variation of breaking Strength with increasing M Green concentration in PVC.

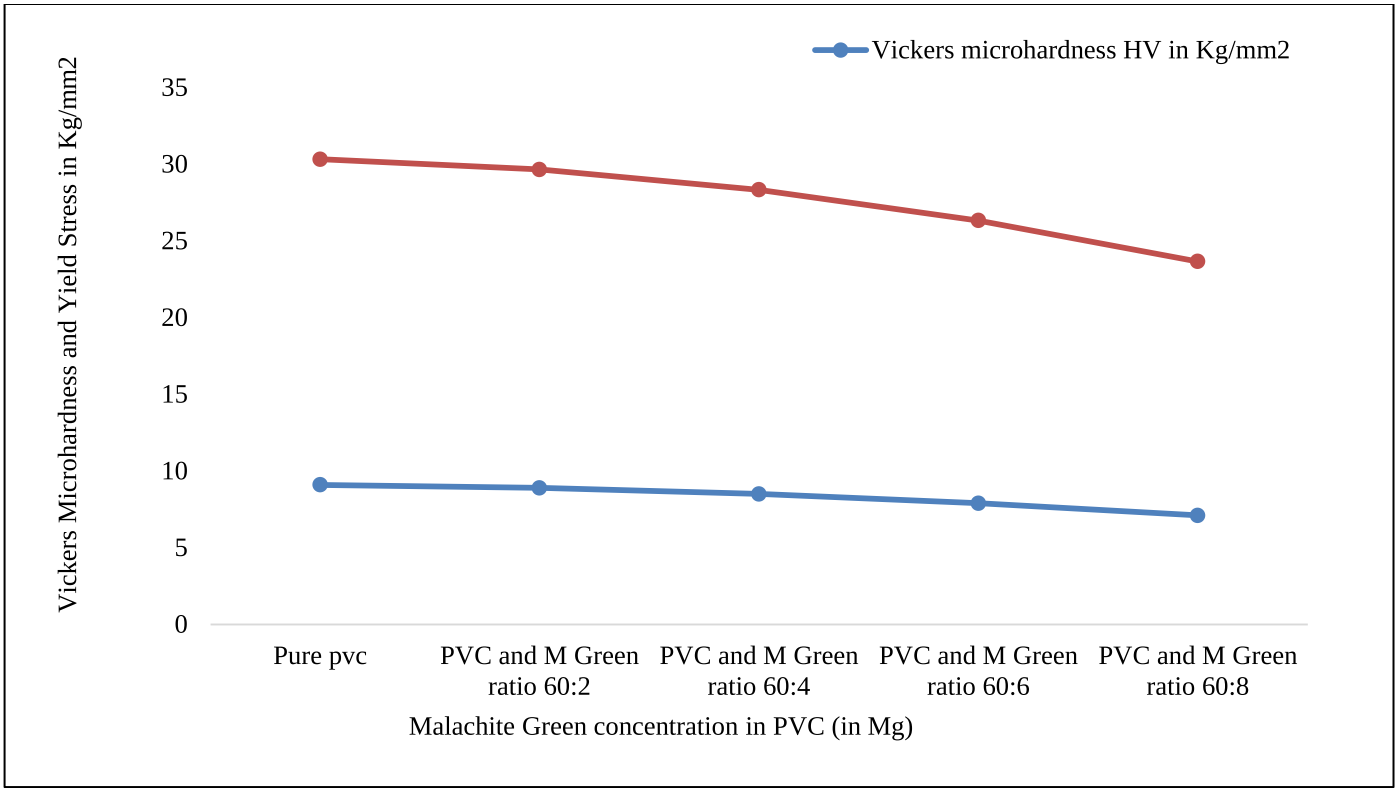

Figure-5: Variation of Vickers Microhardness and Yield Stress with increasing Malachite Green concentration in PVC at applied load 10 Mg.

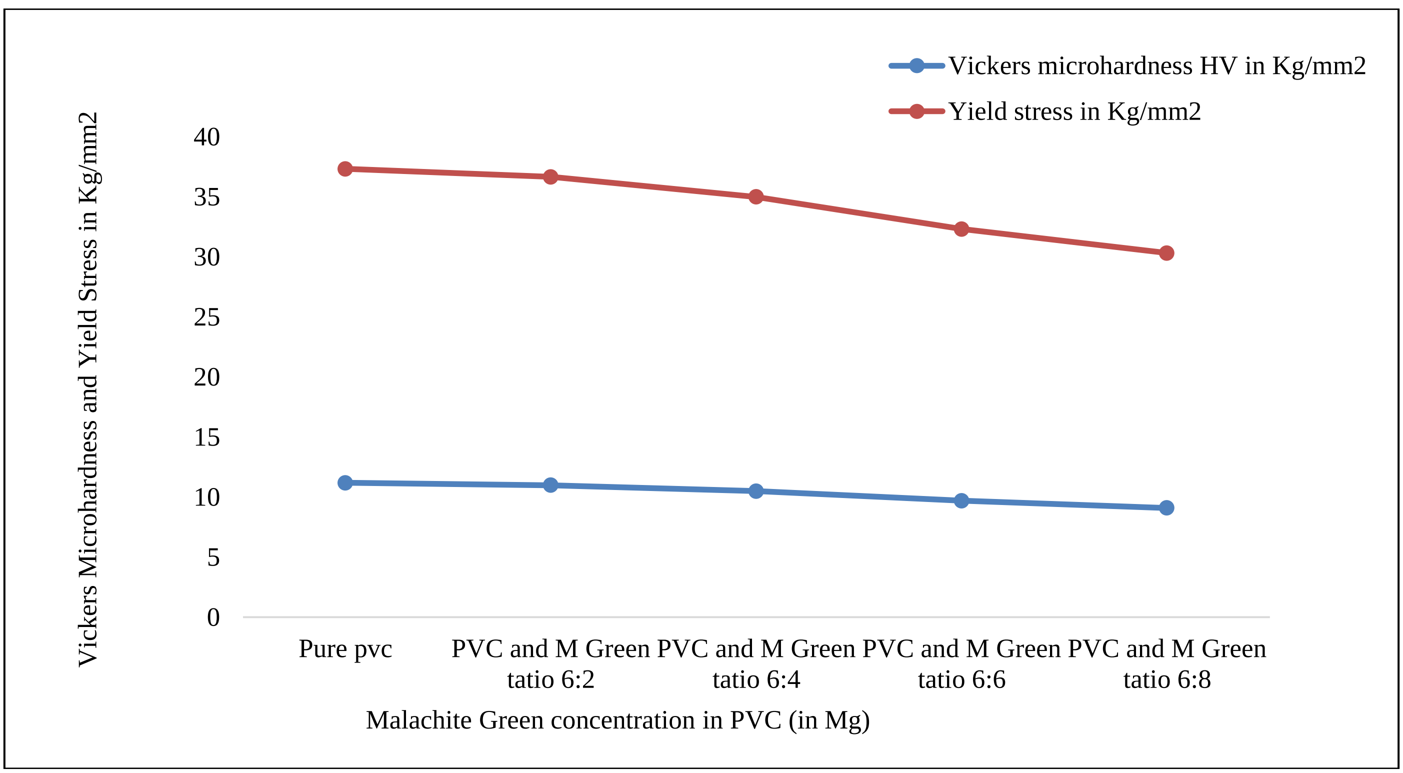

Figure-6: Variation of Vickers Microhardness and Yield Stress with increasing Malachite Green concentration in PVC at applied load 30 Mg.

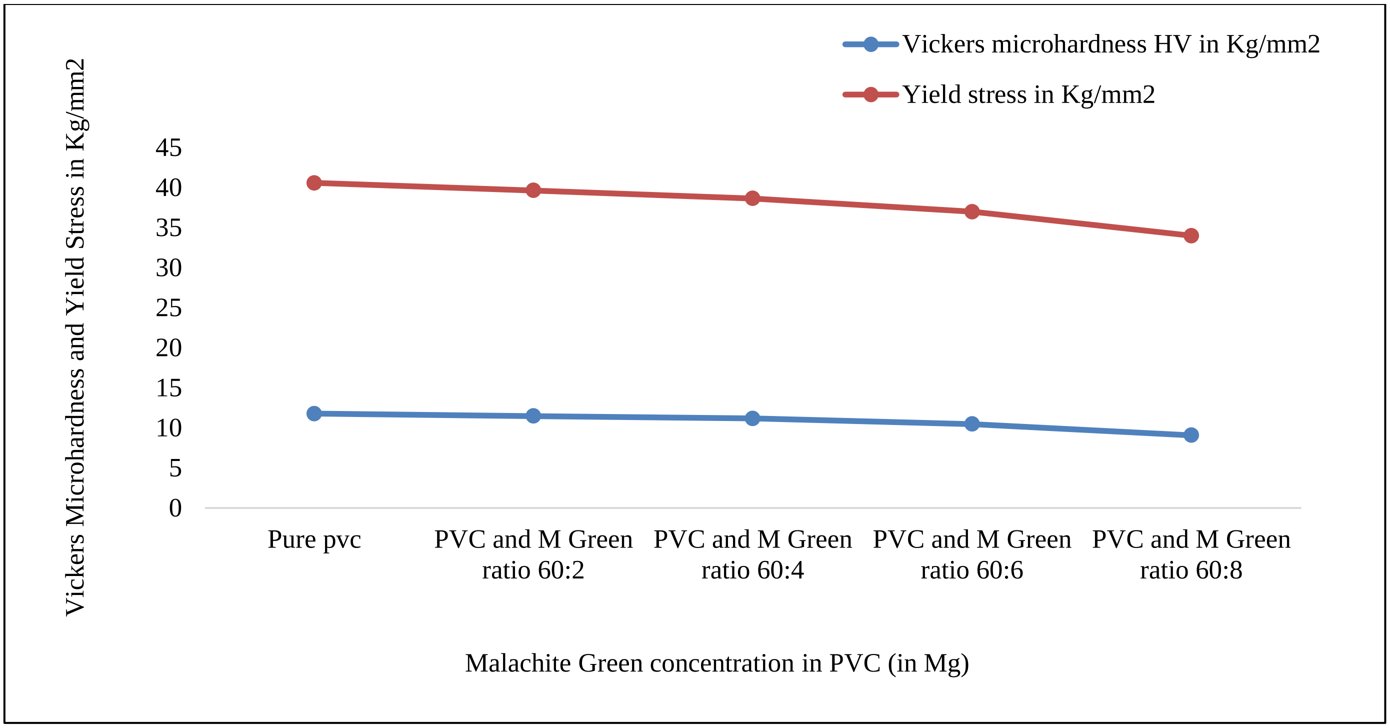

Figure-7: Variation of Vickers Microhardness and Yield Stress with increasing Malachite Green concentration in PVC at applied load 50 Mg

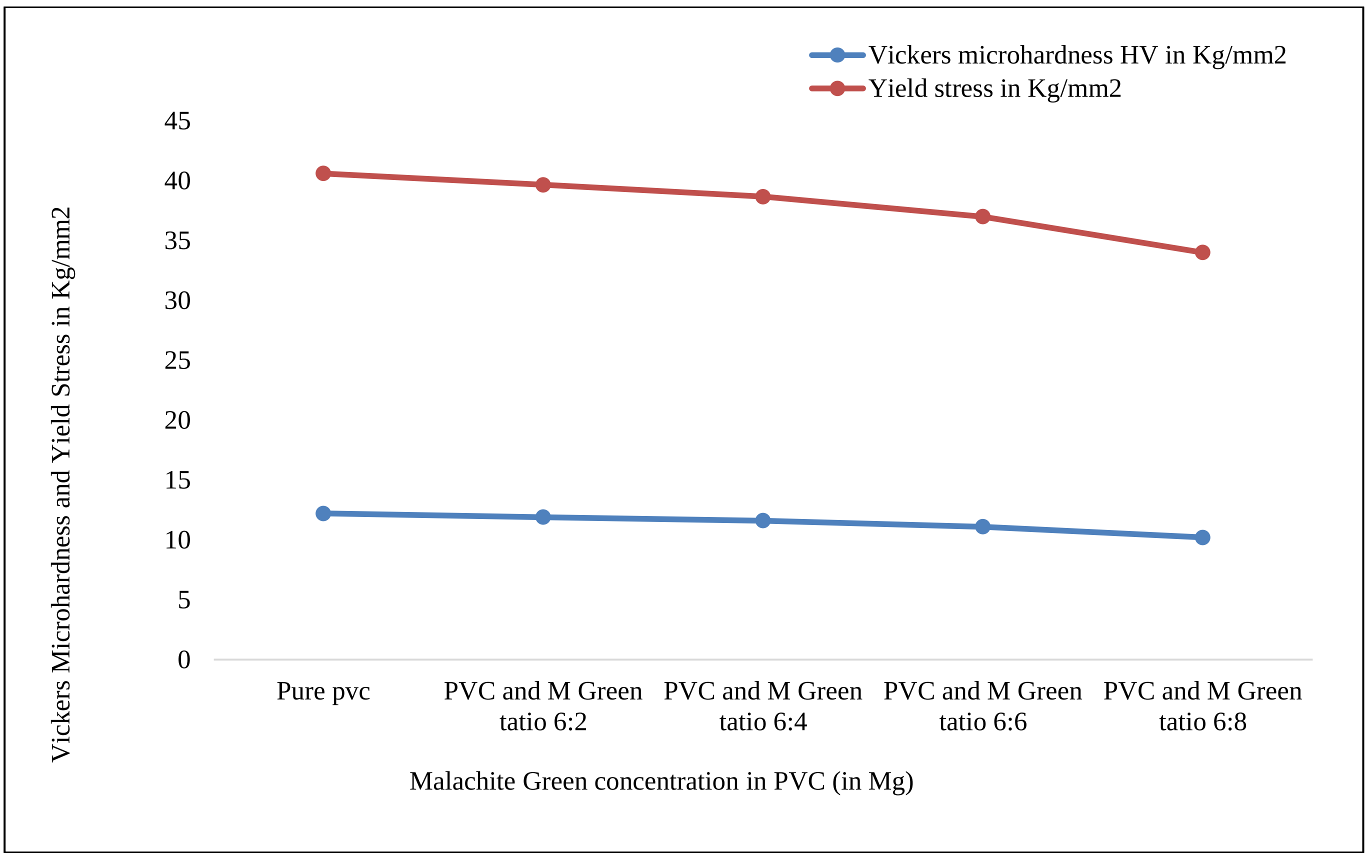

Figure-8: Variation of Vickers Microhardness and Yield Stress with increasing Malachite Green concentration in PVC at applied load 100 Mg

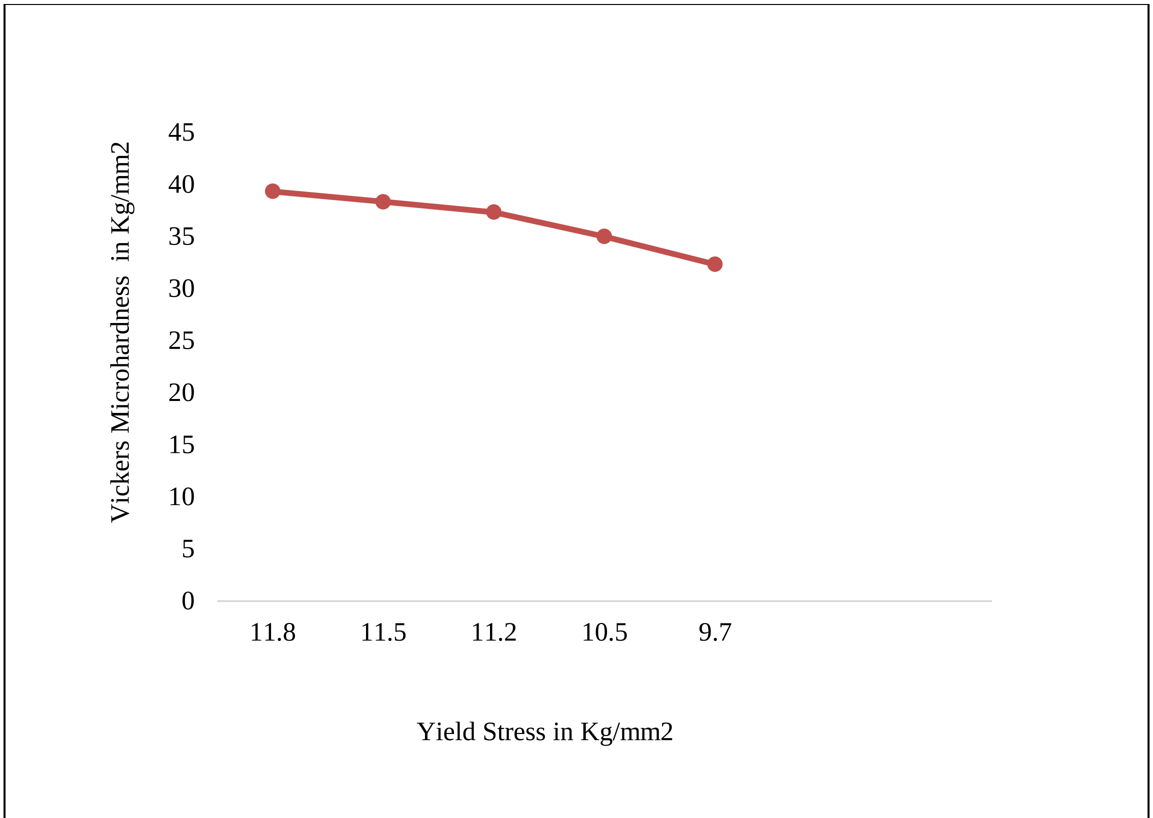

Figure-9: Variation of Vickers Microhardness HV with Yield stress in Kg/mm^2 at load 50 mg

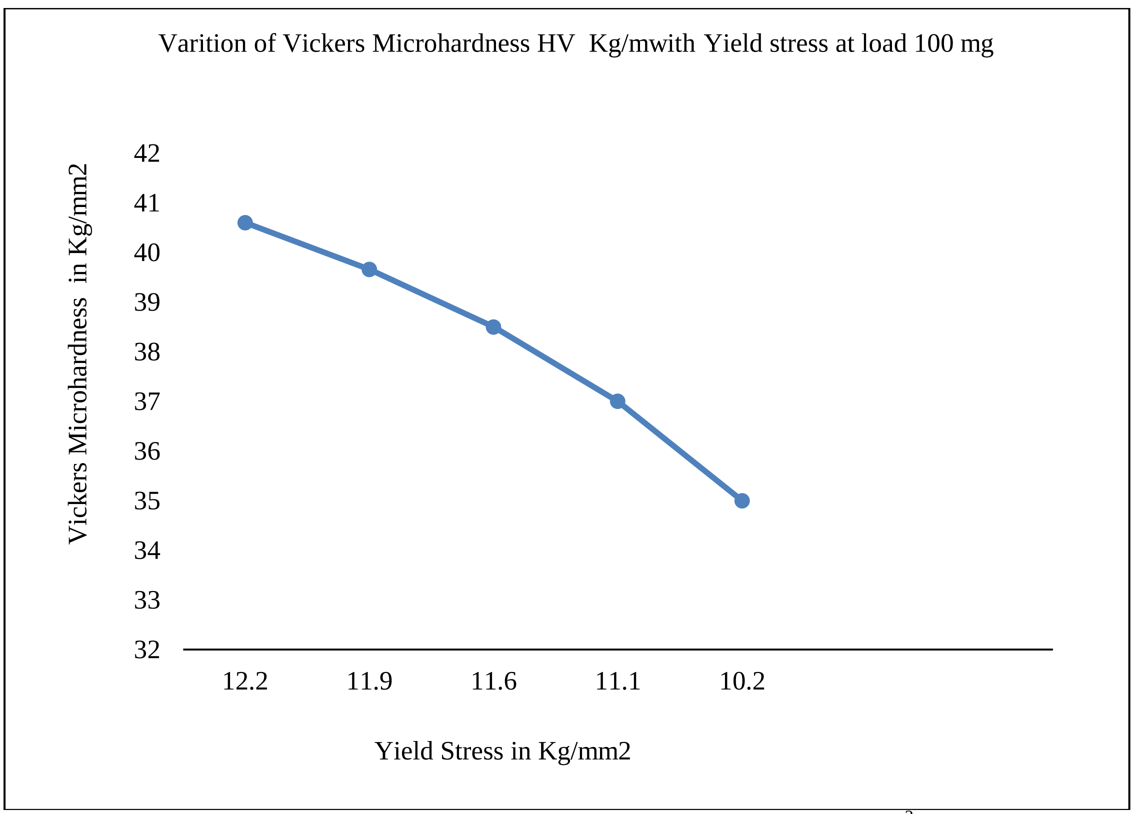

Figure-10: Variation of Vickers Microhardness HV with Yield stress in Kg/mm^2 at load 100 mg

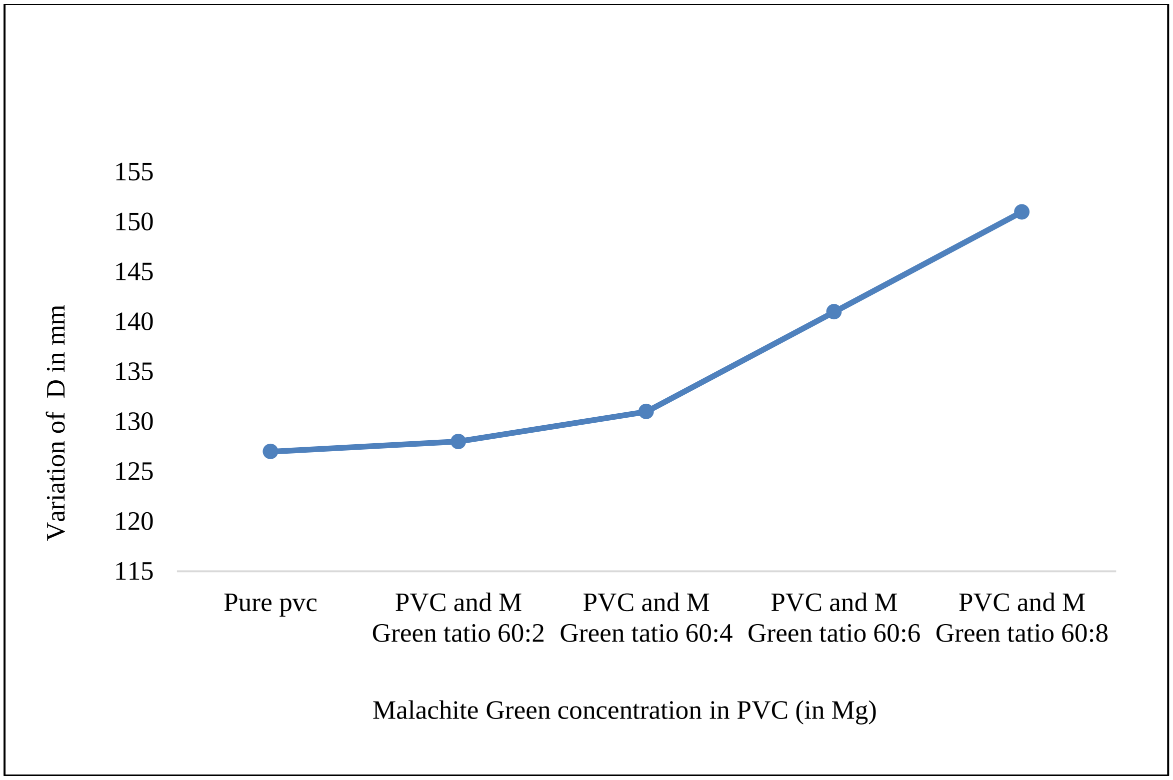

Figure-11: Variation of D with Malachite Green concentration at applied load 50 mg

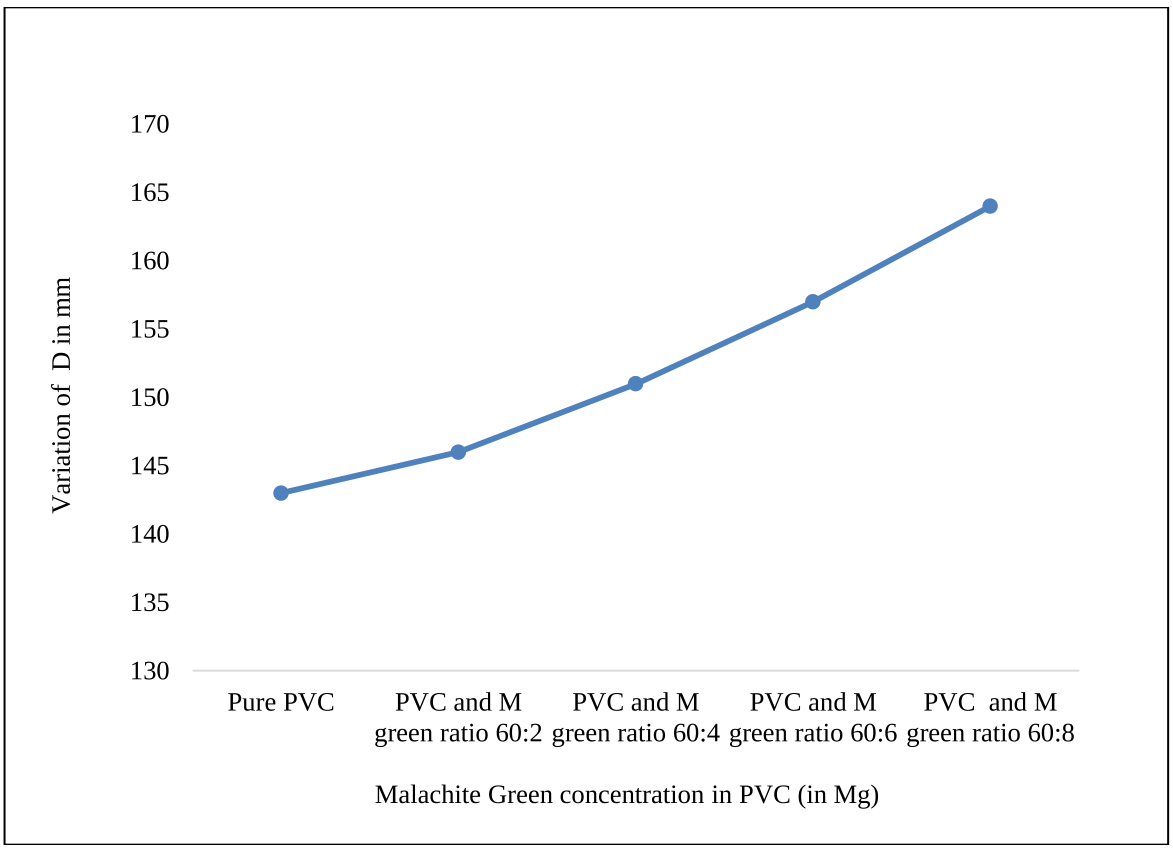

Figure-12: Variation of D with Malachite Green concentration at applied load 100 mg

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