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Preparation, Effect of load on Microhardness of Laser dye Rhodamine (Rh6G) doped with Polymethyl methacrylate polymer networks.

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Abstract:

Polymer composite of laser dye Rhodamine (Rh6G) doped with Polymethyl methacrylate (PMMA) prepared by solution cast method. Various compositions of PMMA: Rh (6G):: 2gm: 0.005mg, 2gm: 0.05mg, 2gm:0.5mg and 2gm pure PMMA ratio polymer networks were prepared. The prepared Rhodamine (Rh6G) doped with Polymethyl methacrylate (PMMA) samples were investigated by the effect of load microhardness. The attainment of saturation value of the Hv with increasing load is determined based on strain hardening phenomena, which are pointed out to micromodes of deformation. The load dependent nature of microhardness of materials, which can be determined with help of strain hardening phenomenon and degree of strain hardening with logarithmic index using Meyer' s law.

Key words: Polymer composite, Microhardness, Micromodes, Meyer' s Law.

Introduction:

Laser dyes are organic compounds that relax radiatively after optical excitation, emitting in the visible or infrared range **[1]**. The first laser dye, phthalocyanine, was discovered in 1966 by Sorokin and Lankard but is seldom employed in lasers today. Only a year later, Rhodamine 6G (Rh6G) was discovered and continues to be the most widely used laser dye. These dyes have a range of practical applications when rigidized in a polymer host. One area that may be revolutionized by the use of organic luminophores in plastics is the flat-screen monitor industry **[2]**. Current thin screens typically use expensive, delicate plasma technology. Organic emitters doped in a polymer layer offer an inexpensive, malleable, and easy-to-produce alternative. Organic dyes are

also of interest for sensors, optical amplifiers, and fiber optics. Rhodamines are important fluorescent dyes, chromophores, for spectral calibration in fluorometers, single-molecule detection, as imaging agents for bio molecules, for scanning confocal microscopy, in fluorescence correlation spectroscopy (FCS), and in high-throughput screening. However, extending their stability further could improve all of these techniques and perhaps lead to novel applications. The thermoplastic PMMA is considered as one of the most competent dye matrices with outstanding optical, thermal, photochemical and dimensional strength. As such, it has been extensively used for laser and non-linear optical materials. The host material, PMMA is a inflexible and unbending polymer with wonderful transparency and superior open-air weathering **[3]**.Moreover, the integration of Rhodamine in the host polymer will apparently stimulate structural and morphological changes. As a consequence of which the mechanical properties are clear to modify. In modern era, microhardness testing has proved to be a appropriate performance to study the mechanical performance of polymeric materials. In this paper, prepared polymer composites were investigated effect of load on microhardness and load dependent nature of microhardness of materials can be determined by strain hardening index of Meyer' s law **[4]**.

2. Experimental:

2.1Materials

The Polymethyl methacrylate PMMA (low molecular weight) in grainy shape as obtained from M/s Research Lab Chem. Industries, Mumbai, India and Rhodamine (Rh6G) and Ammonium Purpurate (Murexide) a crystalline nitrogenous substance having a splendid dichroism, being green by reflected light and garnet-red by transmitted light from Burgoyne, Bridges and Co. Mumbai (India).Composites thin films about 0.45cm in thickness were equipped by the solution cast technique on plane glass substrate within an oven at 333 ºK using Benzene as the widespread solvent. Rhodamine (Rh6G) doped with Polymethyl Methacrylate (PMMA) thin films of various composition of PMMA: Rh (6G):: 2g: 0.005mg, 2gm: 0.05mg, 2gm: 0.5mg and 2g pure PMMA ratio. The samples were out gassed in air for 24 hr, followed by room temperature out gassing at a pressure of about 10^{-4} Torr, for a further period of 24 hrs.

2.2 Load dependent nature of Micro hardness measurement

The Vickers hardness test was developed in the early 1920s as an alternative method to measure the hardness of materials. The Vickers test is often easier to use than other hardness tests since the required calculations are independent of the size of the indenter, and the indenter can be used for all materials irrespective of hardness **[5]**. The basic principle, as with all common measures of hardness, is to observe the questioned materials' ability to resist plastic deformation from a standard source. The Vickers test can be used for all metals and has one of the widest scales among hardness tests. The unit of hardness given by the test is known as the Vickers Pyramid Number (H_v**) [6]**. The hardness number can be converted into units of Pa, but should not be confused with a pressure, which also has units of Pa. The hardness number is determined by the load over the surface area

of the indentation and not the area normal to the force, and is therefore not a pressure.The microhardness of the dry samples were studied with the help of mhp 160 micro hardness tester equipped with a Vicker' s diamond pyramidal indenter having a square base and 136º pyramid angle attached to a Carl Zeiss NU2 universal research microscope. The following relation has been used to calculate the Vicker' s hardness H_v:

$$H_v = \frac{1.854 \times L}{d^2} \quad kg/mm^2$$

Where L is the load in kg and d is the length of the diagonal of indentation, in mm. Indentations at each load were obtained in replicate number and average hardness number was calculated.

The load dependent nature of microhardness of materials can be determined by strain hardening index of Meyer' s law. This gives the relation between load L and length of diagonal d:

$L = a.\, d^{\,n}$

Taking logarithm both sides of the equation, we have

$\log L = \log a + n \log d$

Where, ' a' is constant i.e. load for unit dimension and ' n' is the logarithmic index number which is the measure of strain hardening **[7]**.

4. Result and discussions:

4.1 Effect of load on Microhardness:

Microhardness of a material plays a significant role on the chemical and morphological character of the material, and therefore, by a suitable choice of components of the material, the hardness of the material may be desirably altered. The effect of load on the microhardness of pure PMMA and 0.005mg, 0.05mg, 0.5 mg Rh(6G)doped with PMMA are shown in **Figure(1).**

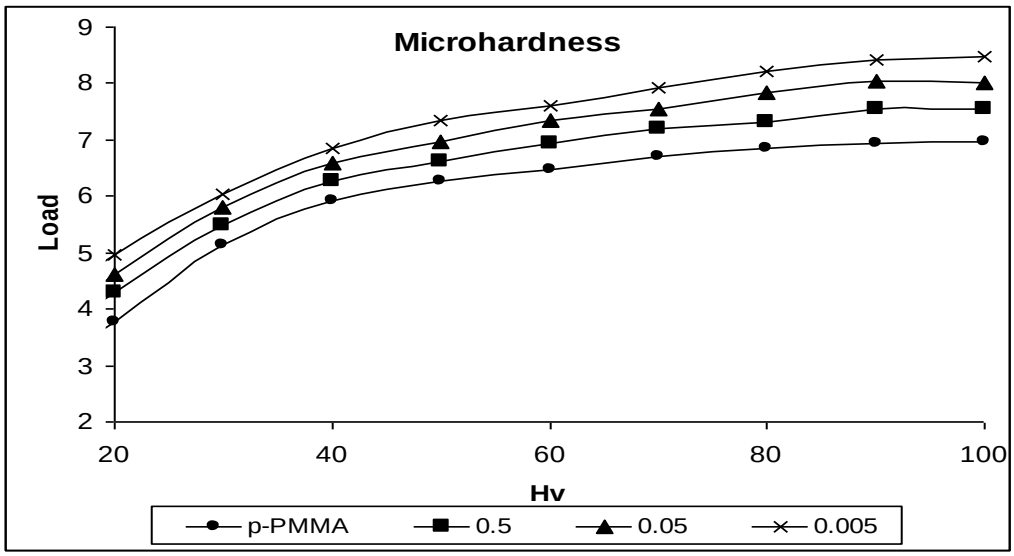

Figure (1). The effect of load on the microhardness of pure PMMA and 0.005mg, 0.05mg, 0.5 mg Rh (6G) doped with PMMA.

The value of Hv is minimum for pure PMMA and maximum for lowest doping of Rhodamine (Rh6G). The microhardness increases on decreasing the doping of Rhodamine (Rh6g) in PMMA. The result also shows that the value of H_v increases curvilinearly with increasing load (10-100 g) for different samples. The increase in H_v with load is due to strain hardening **[8]** in the specimen. It is also noticed that the rate of strain hardening is greater at lower loads. The H_v attains a limiting value beyond the load at 60g for pure PMMA, 70g for 0.5mg, 0.05mg and 80g for 0.005 mg Rh (6G) doped PMMA.. The different values of the microhardness at saturation for pure PMMA, 0.005mg, 0.05mg, and 0.5 mg Rh (6G) doped with PMMA indicate the changes in the macromolecular structure and morphology due to which the related values of microhardness exhibit the hardening or softening characteristic of the material. Based on strain hardening phenomena in the polymers, there is a spectrum of micro mode of deformation in polymer chain. Each micro mode is activated by characteristic temperature and strain conditions. When sufficient number of micro modes becomes active, large-scale plastic deformation begins. According to Amontons and Chery phenomena, the microhardness may be correlated with frictional force. The coefficient of friction decreases with increasing load and the frictional force **[9]** is found to increase linearly with increasing load. Hence, the variation of H_v with load is curvilinear. On applying load, the polymer is subjected to some strain hardening. When H_v value tends to become constant, the polymer is completely strain hardened. The rate of strain hardening in various samples is related to weight percent ratio of polymers in the blend, which governs the degree of cross-linking in the blend. Hence, the different saturation load values are observed for different samples. The saturation value **[10]** of Hv beyond 60g may be due to permanent deformation caused by chain-chain slipping in polymer system.

4.2 Load dependent nature of Micro hardness measurement:

The plots of log L versus log d for 0.005mg, 0.05mg, 0.5 mg (Rh 6G) doped with PMMA and pure PMMA are shown in Fig.2 (a-d). All the plots show two straight lines with different slopes for low load and high load regions. The value for n for 0.005mg, 0.05mg, 0.5 mg (Rh 6G) doped with PMMA and pure PMMA are listed in Table 1. It is evident from Meyer' s law that H_v increases continuously with load (in low load region) when $n > 2$. The value of n approaches around 2 in the saturation load region at which Hv becomes independent of load. Thus, in the low load region where Hv increases with load, the value of n is greater 2. Hence, the logarithmic index number n can be used as a measure of strain hardening.

According to the theory of Pasco and Taber indicates the condition $2 < n > 3$; for explaining the nature of elastic and plastic contacts. According to observation made out of H_v-load studies, the different values of n in different load regions reflect the elastic – plastic characteristic of deformation **[11]**.

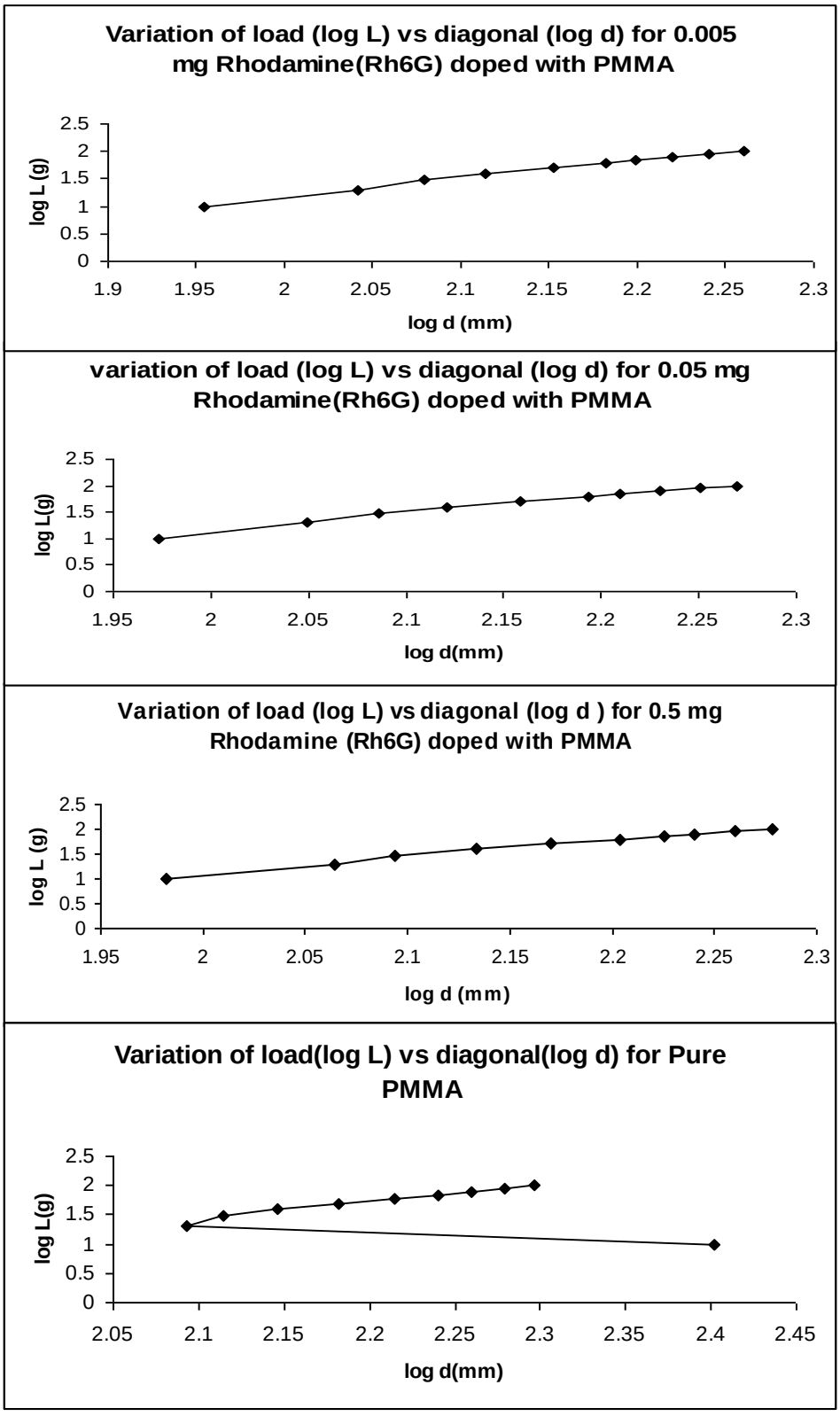

Figure (2) (a-d)Variation on load (log l) vs. diagonal (log d) for pure PMMA and 0.005mg,0.05mg,0.5mg Rhodamine doped PMMA

Table (1): The value of ‘ n’ for 0.005mg, 0.05mg, 0.5mg Rhodamine (Rh6g) doped PMMA and pure PMMA

S.N	SAMPLE PMMA: Rh(6G)	SLOP IN LOW LOAD REGION	SLOP IN HIGH LOAD REGION
1	2g: 0.005mg	2.04	2.22
2.	2g: 0.05mg	2.08	2.23
3.	2g:0.5mg	2.09	2.20
4.	Pure PMMA	2.11	2.21

5. Conclusions:

Macromolecular matrices polymer network structure may be prepared by laser dye Rhodamine (Rh6G) doped with PMMA cross-linking. The morphology of lower content of Rhodamine yields more hardened material in addition, provides greater hardening.. The attainment of saturation value of the H_v with increasing load is determined based on strain hardening phenomena, which are pointed out to micromodes of deformation. When sufficient number of micromodes becomes active, large-scale deformation begins. As the load increases, the specimen is subjected to greater and greater strain hardening. According to the theory of frictional forces the coefficient of friction decreases with increasing load and the frictional force is found to increase linearly with increasing load. Thus, the variation of Hv with load is curvilinear and micromodes initially increase with increasing load. Further, with the help of logarithmic index ‘ n’ known, as Mayer’ s constant be a sign of rate of strain hardening. The different values of ‘ n’ for different specimens reflect the varying degree of strain hardening which indicates the changing morphology and cross-linking in the pure and doped polymers. Consequently, the different values of ‘ n’ in the different load regions reflect the elastic and plastic characteristics of deformation. Thus, the Rhodamine doped PMMA are well matched with changeable morphological facial appearance and mechanical potency with laser dye material for relevance of materials.

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