THE ULTRAVIOLET ABSORPTION OF

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AND UNSTRETCHED STRETCHED

GR-S LATEX FILMS

by

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ABSTRACT

This work on the ultraviolet absorption of stretched and unstretched Type 3 GR-S latex films, was undertaken on the suggestion of Dr. H. D. Smith and Dr. E. Guth, with the expectation that the ultraviolet absorption could give information on the arrangement of the molecules in the stretched state as compared with the unstretched latex. Previous investigators have found that styrene has an absorption band with maximum absorption at 2850 angstroms. Since styrene is one of the constituents of GR-S latex, it was supposed that this absorption band would also appear in any spectral analysis of the latex. To find the nature of this band and its behavior upon stretching the sample was one of the objectives of this research.

The type of spectrograph used for this work was a Hilger E496.303 with a wavelength scale and Spekker photometer attachment. Eastman Type II-F spectroscopic plates were used for all readings. A tungsten steel spark with about 25,000 volts across the electrodes was used as a source for all plates. The unstretched films were prepared by coating a pane of glass with a ten percent solution of zinc chloride, and when dry, the glass was coated with the latex. After drying, a very thin film of rubber was deposited on the glass which could be peeled off as needed. By this method ultraviolet transparent films of initial thickness 0.020 cm. were obtained. These films were stretched into the shape of a spherical bubble by means of nitrogen gas. By calculating the surface areas of the stretched samples and assuming Poisson's Ratio to be 1/2 for rubber, the thicknesses of the stretched samples could be calculated.

A narrow absorption band was found for latex of thickness 0.00260 cm. in the region of 2850 angstroms which did not appear to shift with further stretch. A slight broadening effect upon stretching might have been present but it would not amount to more than 5 or 10 angstroms in either direction. From this it was concluded that the absorption centres of the styrene molecules remained unaffected during stretching. Absorption coefficients were also calculated by Lambert's Law on the assumption that the total loss of radiation was due to absorption. It was found that a decrease in thickness was followed by an increase in the absorption coefficient for a constant wavelength. To obtain the true absorption coefficients, the coefficients computed by Lambert's Law must be corrected for surface reflection and body scattering. This may affect the values of the coefficients but not the position of the band. The increase in scattering with a decrease in thickness is suggested to be due to the existence of microcrystals when the latex is under stress.

THE ULTRAVIOLET ABSORPTION OF STRETCHED AND UNSTRETCHED GR-S LATEX FILMS

I. INTRODUCTION

In comparison with the study of chemical, mechanical, thermal and electrical properties of synthetic rubbers, very little research has been carried out on the optical properties of these substances. Some work has been done on determining the refractive indices, scattering effects, double refraction and absorption in the infra red, but almost nothing on ultraviolet absorption. The present work was undertaken on the suggestion of Dr. H. D. Smith and Dr. E. Guth. Research on the ultraviolet absorption was expected to give information on the arrangement of the molecules in the stretched state as compared with the unstretched state of rubber. Previous investigators have found that styrene has an absorption band with maximum absorption at 2850 angstroms. Since styrene is one of the constituents of GR-S latex, which was used in the investigation, it was supposed that this absorption band would also appear in any spectral analysis of the latex. To find the nature of this band and its behavior upon stretching the sample was one of the objectives of this research.

II. RESEARCH ON SYNTHETIC RUBBERS

The search for synthetic rubbers started almost at once after Charles Goodyear in 1839 discovered the process A few years previous to this discovery, of vulcanization. Faraday in 1826 demonstrated that rubber was essentially a hydrocarbon and found the empirical formula C5Hg. But it was not until 1860 that anyone was successful in breaking down rubber into its constituents. Williams found that by pyrolysis (a cracking process) a water-white, mobile low boiling liquid of the same composition as rubber could be This substance he named isoprene. obtained. Fifteen years later, Bouchardat converted isoprene into an elastic mass and pointed out the monomer polymer relation existing between this material and rubber.

From the time of Bouchardat on, the search for a synthetic product gained momentum with the greatest progress made in the decade preceding the first World War. This was largely because of organized research groups. The most tangible accomplishments of this period were:

- 1. the development by the English groups in collaboration with Auguste Fernbach of the Pasteur Institute of a process for the fermentation of starch to give acetone and a series of higher alcohols.
- 2. the discovery by the German group of organic accelerators of vulcanization. This was independent of the

discovery of these compounds in the United States. Both groups evolved workable processes for the production of isoprene and several of its homologs and for their polymerization induced by heat or by catalysts such as sodium. The products were poor in quality, inferior in elasticity, and in resistance to aging and wear.

After the war, synthetic research was virtually given up except for work at I. G. Farbenindustrie in Germany and duPont in the United States. The main result of this was that many patents were taken out in Germany; but by 1930 the quality of the synthetic materials was still unsatisfactory.

The approach of the chemists failed because the exact molecular configuration of rubber, the mechanism of polymerization whereby isoprene is converted into natural rubber and the way nature is able to perfect this polymerization has remained essentially unknown. A truly rubberlike polymer was not realized until chemists struck out to develop new polymers that might possess the essential properties of the natural product but would be derived from monomers distinctly different in their chemical composition

from isoprene. No synthetic polymer of isoprene has yet been developed that approaches natural rubber in quality or is comparible with the synthetics now being produced.

The first really successful product was developed in 1931 and was called polychloroprene (later called duprene or neoprene). Physically the structure of this synthetic approaches that of natural rubber but chemically it contains 40 percent chlorine. In 1932 Thiokal, an alkylene polysulphide elastic appeared followed in 1933 by Koroseal, a plasticized polyvinyl chloride, and in 1935 by the German buna synthetic rubbers. The buna synthetics or GR-S as they are called in the United States are by far the best synthetics developed and as a result were produced in the greatest quantities during the second World War.

III. PROPERTIES OF GR-S SYNTHETICS

1. General Definition

Synthetic rubbers are those organic substances that possess the property of forcibly retracting to approximately their original size and shape after being greatly distorted. The above definition would also cover the term "elastomer".

2. Comparison Between GR-S and Natural Rubbers

GR-S which used to be known as Buna-S is also made under the proprietary names of Butaprene-S, Chemigum IV, Hycar TT and Buton-S. It has the general properties of natural rubber but in some respects it is superior to it. Its properties can be compared in the following table:

Superior In

Inferior In

1. Abrasion

- 2. Ageing
- 3. Reversion on overcure
- 4. Tendency to scorch in 4. Rate of vulcanization processing
- 2. Heat build up
- 3. Brittleness

1. Dynamic flex cracking

3. Chemical Preparation

(a) GR-S Synthetics in General.

The basic material for all GR-S synthetics is butadiene, a substance that is a gas above -5° Centigrade. Butadiene itself can be prepared by four main processes:

- 1. pyrolysis (or cracking) of higher boiling components of petroleum
- 2. dehydrogenation of some of the lower boiling components of petroleum
- 3. conversion of alcohol $2C_{2}H_{5}OH \longrightarrow CH_{2} = CH - CH = CH_{2} + 2H_{2}O + H_{2}$ alcohol butadiene

4. from acetylene by the substitution of hydrogen



It is very difficult to obtain butadiene of high purity from petroleum products especially when they are products of cracking operations or from agricultural products. The process for obtaining butadiene from acetylene is by far the best method of obtaining a yield of high purity since it is free of side reactions. GR-S is then made from butadiene by an emulsion polymerization process with 20% - 50% styrene added. This involves the formation of new carbon-to-carbon linkages.

(b) Type III GR-S Latex

Type III GR-S latex as was used in the following research consists of:

,	Material	Parts by Weight
	Butadiene	50
	Styrene	50
	Emulsifier	5
-	Potassium per sulphate (K ₂ S ₂ 08)	0.6
	Mercaptan	0.45
	Water	140
The	emulsifier itself contains:	
	Dressinate 731	l
	Dressinate 212	· 9
The	characteristic feature of this to	vne of leter is the

The characteristic feature of this type of latex is that butadiene and styrene exist in equal quantities. It is a white liquid of about the same consistency as creamy milk but has a very strong odor of styrene.

IV. PHYSICAL THEORY OF RUBBER

Elastomers in addition to their well known long range reversibility exhibit other general characteristics.

- (a) Heat is produced upon stretching the elastomer and a cooling effect is noted upon relaxation. This is known as the Joule Heating Effect.
- (b) Stress for a given degree of stretch is a linear function of temperature.

7.

(c) Elastomers when cold harden and at high temperatures they tend to be thermoplastic. They also exhibit both temporary and permanent plasticity. They show a crystalline structure at high stretches which may also occur at low temperatures in the unstretched state.

All types of synthetic rubber consist of atomic chains of very great length (giant molecules) that are built up by the repetition of some unit configuration. These long chains are nearly always formed by the polymerization of the molecules of certain liquids. The double bond attached to a carbon atom at the end of the molecule opens' to form the necessary valence bond for attachment to the next unit. These long chain molecules have freely rotating links and weak secondary forces extending around them, with the result that a loose three dimensional network forms.

From a study of the elastic behavior of rubber, we can make a number of inferences about the size and shape of the molecules. The fact that rubber can be stretched almost reversibly up to 1000 percent with little change in density shows that rubber must contain strong filaments that are mormally crumpled or twisted to less than one-tenth of their extended length. These filaments can slide past one another with very little friction over most of their length but at a few points they are interlocked in a three dimensional network to limit the degree of deformation or flow. There must also be some mechanism that tends to make the filaments and

network return substantially to their original crumpled state after the external stress is removed. Recently methods of statistical mechanics have been applied to this problem of elasticity by E. Guth.

V. THEORY OF ABSORPTION OF LIGHT

When a beam of light falls on matter, the light is either transmitted, reflected or absorbed by the substance. A substance is said to exhibit "general absorption" if it reduces the intensity of all wavelengths of light by nearly the same amount. This means for visible light that the transmitted light shows no marked color change. There is merely a reduction of the total intensity of the white light. No substance is known that absorbs all wavelengths equally; but some, such as films of platinum, approach this condition over a fairly wide range of wavelengths. A substance that absorbs certain wavelengths of light in preference to others is said to show "selective absorption". The color of practically all colored substances is due 'to the existence of selective absorption in some part or parts of the visible spectrum.

When light is absorbed, its energy may be transferred in three ways:

1. the energy may be re-emitted as fluorescent light

2. the molecules that have absorbed the light being now in a higher energy or excited state may enter into chemical reaction or may dissociate. Ultraviolet radiation is known to be very effective in promoting chemical changes

3. the absorbed energy may be changed into heat energy. Lambert's Law states that each layer of equal thickness absorbs an equal fraction of the light that traverses it. If layers of the thickness of a single molecule are considered, then each molecule absorbs an equal fraction of the light that passes by it. This can be stated in the form of an equation

where I_0 = intensity of the light entering the layer.

- x = thickness of the layer.
- I = intensity of the light after passing through the layer.
- K = absorption coefficient since it is a measure of the rate of loss of light from the direct beam.
 This equation may be rewritten as

 $\frac{I}{I_0} = e^{-Kx}$ $\log_{10} \frac{I}{I_0} = -0.4343 \text{ Kx}$ $\log_{10} \frac{1}{T} = 0.4343 \text{ Kx} = E$ where T = transmission = $\log \frac{I}{I_0}$ $E = \text{extinction or optical density} = \log \frac{I_0}{T}$

• • $\log_{10} E = \log_{10} 0.4343 K + \log_{10} x$.

Since the absorption coefficient K varies with the wavelength and thickness x, the shape of the absorption or transmission curve depends upon the term $\log_{10} 0.4343$ k and the height of the curve upon the term $\log_{10} x$.

In a solution the absorption depends upon the concentration and thickness of the layer traversed. This may be expressed by an equation which is known as Beer's Law.

$$I = I_0 e^{-acx}$$

where a = absorption coefficient of unit concentration.

x = thickness.

c = concentration.

 I_0 = entering intensity of light beam.

I = intensity of light after passing through the solution.

No exceptions have ever been found to Lambert's Law, but Beer's Law holds only for certain ranges of concentration; i.e. the absorbing power of a molecule is influenced by the proximity of its neighbors.

VI. EXPERIMENTAL PROCEDURE

The type of spectrograph used for this work was a Hilger E496.303 with a wavelength scale and Spekker photometer attachment. Eastman Type II-F spectroscopic plates were used for all readings. A tungsten steel spark with about 35,000 volts across the electrodes was used as a source for all plates. This source was obtained by using a transformer with a 110 volt primary and 20,000 volt secondary winding in parallel with four Leyden jar condensers in a series parallel hookup. It was found that this gave a very intense source.





Preliminary experiments were conducted on thin sheets of fairly transparent Vulcanized X-224 GR-S of thickness 0.0635 cm. to determine the amount of stretch that could be expected from such a sheet and to determine the best method of stretching. It is known for visible light that with a one way stretch the rubber sample becomes cloudy or "milky" and transmits only a small portion of the incident light beam. However, if stresses are applied both longitudinally and laterally simultaneously, the rubber remains transparent. A surface effect ressembling oxidation was also noted on the surface of the rubber closest to the spark source but on the opposite surface no such effect could be detected. So it was expected that if the experiments were



conducted in an oxygen free atmosphere such an effect could be eliminated. It was decided to use a nitrogen atmosphere which could also serve as the stretching force.

A suitable clamp for the rubber was built which allowed equilateral stress and a nitrogen atmosphere. The holder (fig. 2) consisted of a piece of brass stock drilled to allow a beam of light one square centimeter in area to pass through. A quartz window was glued onto one end and a brass plate fitted onto it to make a strong wall. The rubber sample was placed on the other end and held rigidly in position by means of another brass plate into which grooves were Similar grooves were cut into the main part of the cut. holder and into these the rubber was supposed to "flow" when the plate was tightened up. Into the hollow central part a lead for the nitrogen was drilled and also one for a connection to a mercury manometer. By simply increasing the nitrogen pressure the rubber sample was made to stretch into the form of a sphere or balloon and in this way an equal force in all directions was exerted on the sample.

The next problem encountered was how to measure the thickness of the sample when it was stretched. It was decided to use an optical device to measure this by simply obtaining reflections of a light beam off both surfaces of the rubber sample.



Fig. 3.

The rubber sample was set in such a position that the light beam was incident upon the surface at an angle of 45° and the reflections from both the upper and lower surfaces were then reflected up into a microscope. By measuring the distance between these beams and knowing the magnification of the microscope, the thickness of the sample could be determined. It was found that this was a very efficient method for obtaining the thickness of an unstretched sample but when the sample was stretched its thickness was so reduced that the reflections from the two surfaces appeared in the microscope as a single line. Thus this method was not applicable.

The method of measurement that was finally used was to photograph the bubble against a white background and thus obtain a silhouette of its outline on a photographic plate. By having the camera set up at such a distance that the silhouette obtained was in a ratio of one to one with the bubble, the radius of the spherical surface could be measured directly from the plate. With the radius known the surface area of the film could be calculated. By assuming Poisson's Ratio for rubber to be 1/2, that is, that the volume of the unstretched rubber is the same as the volume of the stretched rubber, the thickness of the stretched film could be determined. It was originally intended to make determinations of the size of the bubble as a function of the pressure exerted upon it by the nitrogen gas. Then by simply reading the pressure from the mercury manometer when the spectrographic plates were being taken, the bubble size could be read directly from the predetermined graphs. But it was found that such a function was not always reproduceable since many factors entered in such as the rate at which the nitrogen gas was allowed to flow into the holder. Thus the bubble size had to be determined at the same time as the spectral analysis was done.

Absorption curves were obtained for vulcanized X-224 GR-S samples of initial thickness 0.0635 cm. but it was found that with maximum stretch for these samples, readings could not be obtained below about 3200 angstroms. These samples then, were not of much value since knowledge of the absorption was desired particularly in the region of 2800 - 2900 angstroms. As these were the thinnest transparent samples that could be obtained from the United States Bureau of Standards it was decided to make very thin films from Type III GR-S latex.

The unstretched films were prepared by coating a pane of glass with a ten percent solution of zinc chloride. When this was dry the glass was coated with the latex. Upon

drying a very thin film of rubber was deposited on the glass which could be peeled off as needed. It was found that with practice films of a very uniform thickness could be made. By this method ultraviolet transparent films of initial thickness 0.020 cm. were obtained which gave the possibility of obtaining experimental results in the ultraviolet region. TABLE

Readings and Calculations Unstretched Sample Thickness = 0.020 cm Surface Area = 1.432 cm² Volume = .0286 cm³

$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Wavelength λ (Angstroms)	Extinction Coefficient E	Percent Transmission	Log Percent Transmission	Total Absorption Coefficient
	6700 5800 5100 4750 4360 4220 4060 3980 3880 3880 3880 3800 3740 3670 3650 3650 3650 3650 3650 3650 3650 3585	.7 .8 .9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.85 1.95 2.0	20.0 15.9 12.6 10.0 7.95 6.32 5.02 3.99 3.16 2.52 2.00 1.59 1.43 1.26 1.12 1.0	$ \begin{array}{r} 1.301\\ 1.201\\ 1.100\\ 1.000\\ .900\\ .801\\ .701\\ .601\\ .500\\ .401\\ .301\\ .201\\ .154\\ .100\\ .049\\ 0.0\end{array} $	$.80 \times 10^{2} \text{ cm}^{-1}$ $.92$ 1.04 1.16 1.27 1.38 1.50 1.61 1.73 1.84 1.96 2.08 2.13 2.19 2.25 2.31

TABLE II

Radius of bubble = 1.00 cm Surface Area = $2\pi \int_{a}^{b} y \left[1 + \frac{dy}{dx}^{2} \right]^{1/2} dx = 2\pi \int_{-.75}^{1.0} r dx = 2\pi (1.0)(1.0 + .75) = 11.00 cm^{2}$ Poisson's Ratio gives final volume = initial volume. $. . .0286 cm^{3} = 11.00 x t$ t = .00260 cm = thickness of sample.

Amount of stretch = $\frac{11.00 - 1.432}{1.432} = 688\%$

Wavelength λ (Angstroms)	Extinction	Percent	Log Percent	Total
	Coefficient E	Transmission	Transmission	Absorption Coefficient
6800 3600 3070 2990 2915 2885 2865 2850 2835 2820 2800 2775 2760 2775 2760 2745 2730 2745 2730 2720 2710	.2 .4 .6 .7 .8 .9 1.0 1.0 1.0 1.0 1.0 1.0 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0	$\begin{array}{r} 63.2\\ 39.9\\ 25.2\\ 20.0\\ 15.9\\ 12.6\\ 10.0\\ 10.0\\ 10.0\\ 10.0\\ 6.32\\ 5.02\\ 3.99\\ 3.16\\ 2.52\\ 2.00\\ 1.59\\ 1.26\\ 1.0\end{array}$	1.801 1.601 1.401 1.301 1.201 1.100 1.000 1.000 1.000 .801 .701 .601 .500 .401 .301 .201 .100 0.0	$1.77 \times 10^{2} \text{ cm}^{-1}$ 3.55 5.32 6.20 7.09 7.98 8.86 8.86 8.86 8.86 10.63 11.52 12.41 13.30 14.20 15.07 15.96 16.83 17.72

Radius of Bubble= 1.25 cmSurface Area= 17.35 cm^2 Thickness= .00165 cmAmount of Stretch= 1110%

Wavelength λ (Angstroms)	Extinction	Percent	Log Percent	Total
	Coefficient E	Transmission	Transmission	Absorption Coefficient
5700 3500 3050 2990 2970 2950 2925 2915 2910 2900 2890 2880 2880 2880 2880 2880 288	.2 .4 .6 .7 .75 .8 .82 .84 .86 .90 .92 .96 .98 1.00 1.05 1.10 1.05 1.10 1.05 1.05 1.05	$\begin{array}{c} 63.2\\ 39.9\\ 25.2\\ 20.0\\ 17.8\\ 15.9\\ 15.2\\ 14.5\\ 13.8\\ 12.6\\ 12.0\\ 11.0\\ 10.5\\ 10.0\\ 8.92\\ 7.95\\ 7.08\\ 7.95\\ 7.08\\ 7.95\\ 8.92\\ 8.92\\ 8.92\\ 8.92\\ 8.92\\ 5.02\end{array}$	$ \begin{array}{c} 1.801\\ 1.601\\ 1.401\\ 1.301\\ 1.250\\ 1.201\\ 1.82\\ 1.161\\ 1.140\\ 1.100\\ 1.079\\ 1.041\\ 1.021\\ 1.000\\ .950\\ .900\\ .850\\ .850\\ .850\\ .900\\ .950\\ .950\\ .950\\ .900\\ .850\\ .801\\ .701 \end{array} $	2.80 $\times 10^2$ cm ⁻¹ 5.59 8.37 9.76 11.0 11.15 11.44 11.72 12.0 12.56 12.83 13.39 13.67 13.95 14.7 15.3 16.1 15.3 14.7 14.7 15.3 16.1 16.1 16.1 16.7 18.2

TABLE II

TABLE IV

Surface Area= 24.86 cm^2 Thickness= .00115 cmAmount of Stretch= 1635%

Wavelength λ (Angstroms)	Extinction Coefficient E	Percent Transmission	Log Percent Transmission	Total Absorption Coefficient	
3600 3070 2890 2880 2875 2870 2865 2860 2850 2849 2848 2849 2848 2847 2845 2840 2840 2840 2837 2835 2830 2815 2800 2790	.2 .4 .7 .74 .8 .82 .84 .86 .9 .9 .9 .86 .84 .82 .84 .82 .84 .86 .9 1.0 1.1 1.2	63.2 39.9 20.0 18.4 15.9 15.2 14.5 13.8 12.6 12.6 13.8 14.5 15.2 15.9 15.9 15.9 15.2 15.9 15.2 15.9 15.2 15.9 15.2 15.9 15.2 15.9 15.2 15.9 15.2 15.9 15.2 15.9 15.2 15.9 15.2 15.9 15.2 15.9 15.2 15.9 15.2 14.5 13.8 12.6 15.9 15.2 15.9 15.2 14.5 13.8 12.6 10.0 7.95 6.32	1.801 1.601 1.301 1.265 1.201 1.182 1.161 1.140 1.110 1.110 1.140 1.161 1.182 1.201 1.182 1.201 1.182 1.161 1.140 1.110 1.000 .900 .801	$\begin{array}{c} 4.0 \times 10^{2} \text{ cm}^{-1} \\ 8.0 \\ 14.0 \\ 14.8 \\ 16.0 \\ 16.4 \\ 16.8 \\ 17.2 \\ 18.0 \\ 17.2 \\ 16.8 \\ 16.4 \\ 16.0 \\ 16.4 \\ 16.8 \\ 17.2 \\ 18.0 \\ 20.0 \\ 22.0 \\ 24.0 \end{array}$	











VII. DISCUSSION OF RESULTS

1. Observation of the Styrene Band

It may be noticed that there is a large difference between the thickness of the unstretched sample and the thicknesses of the stretched samples. The difficulty of obtaining thicknesses between 0.020 cm. and 0.00260 cm. is due to the fact that latex exhibits a tendency to flow; i.e. when under pressure the latex film tended to increase in surface area in a way out of our control. A certain minimum pressure had to be applied in order to stretch the films at all; however, it was possible to produce films of thicknesses 0.0026 cm., 0.00165 cm. and 0.00115 cm. Although the range of thicknesses for stretched samples was relatively narrow, the accuracy of the method used seemed to be high enough to disclose any possible difference in absorption effects.

A narrow absorption band was found for latex of 0.00260 cm. thickness in the region of 2850 angstroms; i.e. at a wavelength where previous investigators have found a band in styrene. As it was impossible to observe this band in unstretched latex (because of the impossibility of preparing sufficiently thin unstretched films of latex) we can only compare the absorption effects relative to varying / stretch. The absorption band does not appear to shift with further stretch but we must not exclude the possibility of a slight broadening effect being present. If there is a broadening of the band, it will not be greater than 5 or 10 angstroms in either direction over a change of thickness of 100 percent. From this it can be concluded that the absorption centre of the styrene molecule remains unaffected when the molecule is stretched. The general shape of the transmission curve seems to be of the same form as those found for natural rubber of similar thicknesses; there is a gradual increase in absorption with a decrease in wavelength¹.

2. Absorption and Stress

The absorption coefficient for a range of wavelengths was calculated by Lambert's Law as if the total loss of radiation was due to true absorption. These absorption coefficients are entered in Tables I to IV.

When light passes through a medium it is reflected and scattered as well as being absorbed. The true absorptiom coefficients can be calculated only if the amount of light lost by reflection and scattering is known. The ratio of the intensities of reflected and incident beams at each surface is equal to $\frac{(n-1)^2}{(n+1)^2}$ where n is the refractive index of the latex. As latex has a refractive index of approximately 1.6 in the ultraviolet region, the loss of intensity due to re-

¹L. A. Wood, "The Optical Properties of Rubber", J. App. Phys. <u>12</u>, 119-126, 1941.

flection on both surfaces will be about 10 to 12 percent.

In the graph of absorption coefficient versus wavelength it will be noticed that a decrease in thickness is followed by an increase in the absorption coefficient for constant wavelength. As the different thicknesses are produced by different stretch, we must assume that the change in the absorption coefficient is due to the changed stress since the absorption coefficient for a uniform material should be constant for a given wavelength regardless of the thickness of the material. This apparent increase in absorption could be due to a greater scattering of light in the latex with increased stress. It is well known that rubber tends to be crystalline at high degrees of stretch which would result in greater scattering. Williams and Taschek¹ and Williams and Dale² found similar changes in the absorption coefficient in the infra red region which they explained in the same way.

¹J. App. Phys., 8, 497-505 (1937). ²J. App. Phys., 15, 585, (1944).

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