

Physical Properties of a Pigmented Silicone Maxillofacial Material as a Function of Accelerated Aging

R. YU, A. KORAN, III, and R. G. CRAIG

The University of Michigan, School of Dentistry, Ann Arbor, Michigan 48109

The effects of accelerated aging on a pigmented elastomer were evaluated by using a weathering chamber. Silastic 44210, a maxillofacial material with proven color and physical property stability, was chosen for pigmentation with 11 maxillofacial pigments. The values of ultimate tensile strength, maximum percent elongation, shear strength, Shore A hardness, and permanent deformation were determined for the pigmented elastomer before and after accelerated aging for 900 h. Results obtained indicate that the incorporation of 0.2% by weight of pigments can alter the physical and mechanical properties of the base elastomer. Accelerated aging had no effect on the physical properties of the pigment/elastomer combinations.

J Dent Res 59(7):1141-1148, July 1980

Introduction.

Two major problems are associated with maxillofacial prostheses used to rehabilitate patients with extra-oral-facial deformities. They are: 1) the degradation of static and dynamic physical properties of the elastomers, and 2) discoloration of these prostheses in a service environment.

Although many materials and techniques are currently available, scientific studies dealing with the physical properties and color stability of these materials are yet very limited. In 1969, Cantor and co-workers¹ published a study on methods for evaluating various prosthetic facial materials. After examining the results of the physical and mechanical properties of several materials, they concluded that plasticized poly(methyl methacrylate) was best suited for maxillofacial applications

since it had good tear resistance and percent elongation. Reflectance spectrophotometry was also used to analyze the color of human skin and maxillofacial pigments.

Walter,² in 1970, reported on the physical properties of an acrylic ester resin, Palomed; a dimethyl polysiloxane, Molloplast B; a silicone rubber, Verone R.S.; and a pourable latex rubber, Qualitex P.V. The results of clinical trials indicated that the high compressibility and good tissue tolerance of Palomed were improvements over harder materials.

The important criteria for maxillofacial materials were described by Chalian, Drane, and Standish in 1971.³ They were: ease of application and retention, color stability, durability, lack of toxicity, strong peripheries, translucency, ease of cleansing, light weight, ease of fabricating, and physical and chemical inertness.

Sweeney and his associates,⁴ in 1972, published a tentative specification for maxillofacial materials. Several materials were evaluated, and a plasticized polyvinyl chloride appeared promising. Although an accelerated aging chamber was used to test color stability, the effects of accelerated aging on the physical and mechanical properties of these materials were not reported.

Properties of a plasticized polyvinyl chloride, one silicone elastomer, several formulations of an aliphatic polyether urethane, and two aromatic polyester urethane systems were reported by Goldberg⁵ in 1977. All materials were tested for physical property stability, hydrolytic stability, stain resistance, and color stability. The aliphatic polyether urethane was particularly promising.

Results were reported by Lewis *et al.*⁶ in 1977 on several new maxillofacial materials, including a silphenylene, an aliphatic polyurethane, and a new RTV silicone,

Received for publication August 14, 1978

Accepted for publication September 17, 1978

This study was supported by U.S. Public Health Service Grant DE 04136 from the National Institute of Dental Research, National Institutes of Health, Bethesda, MD 20014.

Silastic 44210. They concluded that the RTV silicone was especially promising for maxillofacial applications with excellent mechanical properties, ease of processing, and low cost.

Fine,⁷ in 1978, discussed color characterization of elastomers for maxillofacial applications. In this paper, the color terminology, relationship of color and light sources, the general properties of colored objects, colorants and human skin, and color matching and color reproduction were reported. In the same year, Fine and his co-workers⁸ described a new technique for intrinsic and extrinsic coloring of silicone maxillofacial elastomers with the use of inorganic pigments. This technique utilized colored tabs to match the patient's skin color. The reported results of color matching for facial prostheses were very encouraging.

More recently, Craig, Koran, and Yu⁹ reported on the color stability and physical property stability¹⁰ of various commercial maxillofacial elastomers under conditions of accelerated aging. They quantitatively evaluated a plasticized polyvinyl chloride, a polyurethane, and three RTV and one HTV silicones. In these studies, the silicones, particularly one RTV silicone, were most stable. In a later study, the color stability of 11 maxillofacial pigments incorporated into an elastomer with proven color stability was also evaluated under conditions of accelerated aging.¹¹ Several pigments changed in color when exposed to accelerated aging.

Although many articles dealing with the techniques of color matching and reproduction for maxillofacial prostheses are available, a review of the pertinent literature indicates that studies concerning the effects of pigments on the physical and mechanical properties of the base elastomers, and the effects of pigment degradation on these properties as a result of accelerated aging, have not been reported. The purpose of the present study was to investigate the effects of accelerated aging on the physical and mechanical properties of a pigmented maxillofacial elastomer. The effect of pigments on the properties of the elastomer prior to aging was also studied.

the effect of pigments on a maxillofacial material for the following reasons: 1) the pre-polymer is a moderately viscous fluid; 2) in the previous studies,^{9,11} it was demonstrated to be color stable and easily pigmented; 3) it is processed at room temperature; 4) it is simple and convenient to process; and 5) when polymerized, it possesses excellent physical and mechanical properties, and these properties are not altered by accelerated aging.¹⁰ Since this study dealt primarily with the effects of accelerated aging on the physical properties of a pigmented maxillofacial material, Silastic 44210 was selected to minimize the complications which might otherwise be attributed to the changes in the elastomer itself.

Eleven dry, mineral earth pigments[†] were used to color the silicone elastomer. These pigments were: white (W), yellow (Y), dark buff (DBf), medium brown (MB), light brown (LB), red-brown (RB), black (Bl), red (R), Blue (Bu), light orange (LO), and orange-yellow (OY). All pigments were incorporated into the silicone elastomer at 0.2% by weight, following the same procedure as that described in the previous study.¹¹ The samples were prepared by incorporating each pigment into the silicone base, then catalyzing and processing the mix in an aluminum mold according to the manufacturers' instructions, and under vacuum to eliminate porosities. Prior to accelerated aging, the ultimate tensile strength, maximum percent elongation, shear strength, Shore A hardness, and permanent deformation after break were determined for each pigment/elastomer combination. For ultimate tensile strength and maximum percent elongation determinations, dumbbell-shaped samples of dimensions 0.7 x 0.2 cm with two gauge marks 3.5 cm apart were stretched at a constant elongation rate of 10 cm/min with an Instron Tensile Tester.[‡] The ultimate tensile strength was described as the maximum load at sample rupture per unit initial cross-sectional area. The maximum percent elongation was calculated by dividing the length of the sample between the gauge marks at rupture by the initial length be-

Materials and methods.

Silastic 44210* was chosen to evaluate

*Dow Corning Corporation, Midland, MI

†Artskin Products, Inc., Norfolk, VA

‡Instron Corporation, Canton, MA

tween the gauge marks, and reported as percent of the original length of the sample. The shear strengths were determined by following the procedures outlined in ASTM D732-46, the standard test method for the shear strength of plastics.¹² The hardness values were measured on samples having a thickness of 1.0 cm with the use of a Shore A Durometer,[†] and the readings obtained 5 sec after indentation were recorded as Shore A hardness units. Following the ultimate elongation of a tensile sample, the increase in length was measured after 24 h of elastic recovery with no stress and divided by the original length of the sample before elongation. This ratio is termed permanent deformation and is represented as the percentage of the original length. The determination of permanent deformation by this approach is very important because it is a technique relevant to the mode of failure frequently occurring around the thin edges of a prosthesis under service conditions.

Duplicate samples were then placed in a Weather-Ometer,[§] having a 2500 watt Xenon light source with borosilicate filters that produced an energy spectrum similar to that of natural sunlight.¹³ During accelerated aging, the light was left on continuously, and distilled water was sprayed on the samples for 18 of every 102 min. The humidity of the chamber was 90% RH, and the temperature was maintained at 43°C or a black panel temperature of 63°C.

In order to evaluate the effects of the pigments on the elastomer, control samples were prepared from the silicone base and tested along with the pigmented samples for comparison. Samples of each pigment and the control were withdrawn from the aging chamber for physical property determinations at time intervals of 300, 600, and 900 h. Five samples were used for each pigment/elastomer combination and at each time interval of accelerated aging. The means and standard deviations were calculated for each pigment/elastomer combination. The control means were compared to pigmented sample means before and after aging by Tukey's multiple comparison test at a 95% level of confidence.¹⁴

Results.

Results of the physical and mechanical testing before and after aging are summarized in Tables 1 through 5. In each table, the vertical lines represent no statistical differences in mean values with respect to control. The corresponding Tukey's intervals are listed in the footnotes of each table.

Results in Table 1 show that before accelerated aging, seven of the 11 pigments did reduce the ultimate tensile strength of the elastomer. They were Y, OY, LB, DBf, W, MB, and Bl. The largest change was observed for the yellow pigment (Y), with a value of 37.7 kg/cm² or a decrease of 20.7%. No practical differences in ultimate tensile strength were observed for any pigmented samples before and after aging for 900 h.

The results for maximum percent elongation are given in Table 2. Incorporation of the pigments into the silicone imparted only slight changes in percent elongation. Only four of the pigment/elastomer combinations were statistically different from the control after 900 hours of aging. Prior to aging, the largest decrease in percent elongation was with dark buff (DBf) at 431% or a decrease of 4.4%. Similar to the results for ultimate tensile strength, no practical changes in percent elongation were seen as a result of accelerated aging.

In Table 3 the shear strength values are shown. When comparing the pigmented samples to the control (unpigmented elastomer), the shear strength of the elastomer was affected by the addition of ten of the 11 pigments. A decrease was found for Y and OY both at 20.4 kg/cm², but an increase was found for others such as: MB (25.5 kg/cm²), Bu (25.4 kg/cm²), LB (25.6 kg/cm²), RB (25.6 kg/cm²), Bl (25.9 kg/cm²), DBf (25.5 kg/cm²), W (26.0 kg/cm²), and R (25.6 kg/cm²). The shear strength for the control was 24.3 kg/cm², which was statistically the same as the LO pigment with a strength value of 25.1 kg/cm². Again insignificant practical changes in shear strength were observed after accelerated aging for all 11 pigments.

The results for Shore A hardness are presented in Table 4. The Shore A hardness of the base elastomer was decreased by the addition of each pigment. Prior to aging, the greatest reduction among the 11 pigments was observed for Y with a 30.9% change.

[†]The Shore Instrument and Manufacturing Co., Jamaica, NY

[§]Model 25 WR, Atlas Electric Devices, Chicago, IL 60613

TABLE 1
ULTIMATE TENSILE STRENGTH OF PIGMENTED SILICONE 44210
AS A FUNCTION OF AGING

Pigment	Tensile Strength kg/cm ²		Hours of Aging					
			0	300	600	900		
Yellow	37.7	(1.1)*	38.8	(1.1)	38.8	(0.9)	39.0	(1.4)
Orange-Yellow	40.0	(1.4)	40.5	(1.6)	41.4	(1.8)	40.6	(1.4)
Light Brown	41.8	(3.5)	41.2	(0.8)	41.1	(1.1)	41.7	(1.9)
Dark Buff	40.8	(3.5)	41.2	(1.8)	41.2	(2.0)	42.3	(1.9)
White	42.9	(2.8)	43.0	(1.1)	43.2	(1.1)	42.4	(2.4)
Medium Brown	41.1	(2.8)	42.6	(1.5)	41.8	(2.6)	42.4	(1.6)
Black	43.1	(1.5)	43.1	(1.2)	44.4	(1.7)	44.2	(0.8)
Red	44.1	(4.0)	44.3	(1.2)	44.8	(2.1)	44.6	(0.7)
Red-Brown	45.7	(2.7)	44.8	(0.6)	44.8	(3.2)	44.9	(1.4)
Blue	44.1	(2.7)	45.1	(1.7)	44.3	(2.4)	45.0	(1.9)
Control	45.5	(1.0)	44.8	(0.8)	44.9	(1.0)	45.4	(0.9)
Light Orange	45.0	(1.3)	44.1	(0.6)	46.2	(3.1)	46.2	(1.7)

*Values in parentheses are standard deviations.

Tukey Interval for Times = 1.2; for Pigments = 2.2.

Vertical line indicates no statistical difference for pigments with respect to control.

TABLE 2
MAXIMUM PERCENT ELONGATION OF PIGMENTED SILICONE 44210
AS A FUNCTION OF AGING

Pigment	Elongation %		Hours of Aging					
			0	300	600	900		
Dark Buff	431	(20)*	441	(12)	440	(17)	441	(15)
Light Brown	442	(17)	439	(15)	440	(13)	438	(16)
Black	446	(14)	438	(12)	448	(8)	438	(3)
Red-Brown	437	(13)	444	(9)	446	(16)	441	(12)
White	446	(10)	438	(12)	441	(18)	442	(15)
Blue	446	(9)	442	(4)	442	(13)	446	(19)
Medium Brown	442	(17)	443	(12)	441	(15)	447	(16)
Light Orange	453	(7)	443	(10)	457	(16)	453	(10)
Control	451	(8)	450	(12)	452	(11)	457	(8)
Red	455	(21)	440	(9)	445	(17)	458	(12)
Orange-Yellow	467	(11)	455	(8)	458	(15)	459	(12)
Yellow	467	(12)	482	(9)	468	(9)	471	(20)

*Values in parentheses are standard deviations.

Tukey Interval for Times = 9; for Pigments = 15.

Vertical line indicates no statistical difference for pigments with respect to control.

Percent elongation = (length of sample at break/initial length) x 100.

TABLE 3
SHEAR STRENGTH OF PIGMENTED SILICONE 44210
AS A FUNCTION OF AGING

Pigment	Shear Strength kg/cm ²		Hours of Aging					
			0		300		600	
Yellow	20.4	(0.5)*	20.5	(0.8)	20.5	(0.8)	20.4	(0.4)
Orange-Yellow	20.4	(0.5)	21.0	(1.0)	20.4	(0.7)	20.2	(0.7)
Medium Brown	25.5	(0.7)	25.3	(0.8)	25.4	(0.7)	25.3	(1.0)
Blue	25.4	(0.5)	24.8	(0.5)	25.5	(0.7)	25.4	(0.9)
Light Orange	25.1	(1.0)	24.9	(0.8)	25.4	(0.8)	25.0	(0.8)
Control	24.3	(0.5)	24.7	(0.5)	24.1	(0.9)	24.0	(0.6)
Light Brown	25.6	(1.0)	25.2	(0.6)	24.6	(0.7)	25.1	(0.3)
Red-Brown	25.6	(0.6)	25.3	(0.9)	25.5	(0.9)	25.6	(0.6)
Black	25.9	(1.0)	25.3	(0.6)	25.6	(1.2)	25.5	(0.7)
Dark Buff	25.5	(1.4)	25.4	(0.9)	25.0	(0.8)	25.7	(0.9)
White	26.0	(0.6)	25.5	(0.7)	25.6	(1.0)	26.0	(0.8)
Red	25.6	(0.9)	25.6	(0.5)	25.1	(0.7)	25.2	(0.5)

*Values in parentheses are standard deviations.

Tukey Interval for Times = 0.4; for Pigments = 0.9.

Vertical line indicates no statistical difference for pigments with respect to control.

TABLE 4
SHORE A HARDNESS OF PIGMENTED SILICONE 44210
AS A FUNCTION OF AGING

Pigment	Hardness		Hours of Aging					
			0		300		600	
White	30.2	(0.4)*	30.2	(0.4)	30.2	(0.4)	30.2	(0.4)
Yellow	22.4	(0.5)	22.2	(0.4)	22.6	(0.5)	22.2	(0.8)
Dark Buff	30.4	(0.5)	30.2	(0.4)	29.8	(0.4)	29.6	(0.5)
Medium Brown	28.6	(0.8)	28.8	(0.8)	30.0	(0.6)	30.2	(0.4)
Light Brown	28.6	(0.8)	28.8	(0.8)	28.8	(0.4)	29.4	(0.5)
Red-Brown	31.2	(0.4)	31.0	(0.6)	31.2	(0.4)	31.0	(0.6)
Black	29.2	(0.4)	30.2	(0.4)	30.2	(0.4)	31.0	(0.6)
Red	30.2	(0.4)	30.4	(0.5)	30.4	(0.5)	30.4	(0.5)
Blue	30.2	(0.8)	30.6	(0.5)	30.6	(0.5)	30.8	(0.4)
Light Orange	28.6	(0.5)	28.4	(0.5)	28.6	(0.5)	28.8	(0.4)
Orange-Yellow	23.8	(0.8)	24.2	(0.8)	24.8	(0.8)	23.8	(0.8)
Control	32.4	(1.0)	32.6	(0.8)	32.6	(1.0)	32.8	(0.7)

*Values in parentheses are standard deviations.

Tukey Interval for Times = 0.3; for Pigments = 0.7.

TABLE 5
PERMANENT DEFORMATION OF PIGMENTED SILICONE 44210
AS A FUNCTION OF AGING

Pigment	Permanent Deformation %	Hours of Aging						
		0	300	600	900			
White	0.30	(0.08)*	0.40	(0.06)	0.24	(0.08)	0.22	(0.07)
Yellow	0.34	(0.06)	0.36	(0.08)	0.30	(0.09)	0.20	(0.06)
Dark Buff	0.36	(0.07)	0.24	(0.06)	0.24	(0.06)	0.26	(0.08)
Medium Brown	0.32	(0.09)	0.36	(0.06)	0.34	(0.06)	0.36	(0.08)
Light Brown	0.30	(0.05)	0.30	(0.09)	0.26	(0.06)	0.24	(0.07)
Red-Brown	0.40	(0.06)	0.36	(0.06)	0.24	(0.04)	0.30	(0.07)
Black	0.38	(0.07)	0.34	(0.05)	0.28	(0.07)	0.22	(0.07)
Red	0.42	(0.05)	0.28	(0.07)	0.32	(0.08)	0.30	(0.09)
Blue	0.36	(0.08)	0.32	(0.06)	0.28	(0.07)	0.22	(0.05)
Light Orange	0.34	(0.06)	0.30	(0.04)	0.30	(0.06)	0.26	(0.08)
Orange-Yellow	0.42	(0.05)	0.32	(0.05)	0.24	(0.08)	0.24	(0.08)
Control	0.34	(0.08)	0.24	(0.06)	0.28	(0.08)	0.28	(0.07)

*Values in parentheses are standard deviations.

Tukey Interval for Times = 0.06; for Pigments = 0.14.

Deformation = change in length/original length x 100 24 hours after rupture.

Vertical line indicates no statistical difference for pigments with respect to control.

Shore A hardness of the pigmented samples ranged from 22.4 to 31.2 Shore A hardness units compared to 32.4 for the control. Unlike the results for ultimate tensile strength, maximum percent elongation, and shear strength, accelerated aging did cause changes in Shore A hardness for some of the pigmented specimens. Changes occurred for DBf (from 30.4 to 29.6 Shore A hardness units), LB (from 28.6 to 29.4 Shore A hardness units), MB (from 28.6 to 30.2 Shore A hardness units), Bu (from 30.2 to 30.8 Shore A hardness units), and Bl (from 29.2 to 31.0 Shore A hardness units) after 900 h of aging. Although the changes observed are statistically significant, they are probably insignificant in clinical application.

Table 5 summarizes the results of permanent deformation. Determination of this deformation is essential in evaluating the potential for permanent dimensional change around the thin edges, as a result of stress on the peripheries of maxillofacial appliances under service environment. Unlike the

results for other physical and mechanical properties, the incorporation of pigments had no effect at all on the permanent deformation of the resulting elastomers. Accelerated aging caused slight changes in the permanent deformation for W, Y, DBf, RB, Bl, R, Bu, and OY; however, these changes would not be clinically significant.

Discussion.

The results obtained from physical and mechanical testing of pigmented Silastic 44210 samples suggest that accelerated aging caused little or no change in the overall properties of the resulting elastomers. However, incorporation of pigments into the silicone base can vary the initial physical and mechanical behavior of the elastomer.

The reductions observed in ultimate tensile strength, maximum percent elongation, and Shore A hardness for LB, DBf, W, MB, Bl, R, RB, Bu, and LO were the direct result of polymer pigment interactions. When these pigments were incorporated into

the polymer matrix, the results obtained for physical and mechanical properties were largely contributed by physical interactions and were not of chemical origin. If there were a chemical reaction between the pigment and the elastomer, the result of chemical bonding between polymer and pigments would be reinforcement,¹⁵⁻¹⁸ whereas in physical interactions, pigment particles can be treated as inert media, in that their presence has been accounted for by simple geometric modification of the elastic chains in a polymer network and a reduction in the numbers of chains passing through a unit cross-sectional area of the sample. No reinforcement can be expected in this case, but a reduction in physical and mechanical strength of the elastomer could result.^{19,21} While this behavior was demonstrated for ultimate tensile strength, maximum percent elongation, and Shore A hardness, the noted increase in shear strength was probably a result of the increase of interfacial friction on the shearing surfaces. When the two surfaces are caused to slide against each other by a shearing force, the distribution of pigment particles on the surface increases the surface roughness, and therefore increases the shear strength.

In the case of Y and OY, addition of these two pigments probably hindered the polymerization kinetics or changed the polymerization mechanism. Therefore, the result of this type of pigment/elastomer combination is a decrease in the crosslink density. This effect is reflected in a decrease in the elastic behavior of the polymer/pigment combination, an increase in the viscous characteristics as reflected by a decrease in ultimate tensile strength, and an increase in maximum percent elongation.

Although the addition of pigments changed some of the physical and mechanical characteristics of the elastomer, they did not substantially reduce the elastic free energy of the elastomer to hinder the dimensional recovery after elongation. This was substantiated in the results of permanent deformation measurements. These results show that Silastic 44210, with and without pigments, had good dimensional stability. The permanent deformation observed averaged only 0.35%.

Conclusions.

The results indicate that addition of

pigments can vary the physical and mechanical properties of a maxillofacial material. However, the changes observed in this study using Silastic 44210 and mineral earth pigments were not large enough to compromise the use of the material clinically.

The physical and mechanical properties of samples prepared from combinations of each of the 11 maxillofacial pigments with Silastic 44210 showed little or no change after 900 h of accelerated aging in a Weather-Ometer.

REFERENCES

1. CANTOR, R.; WEBBER, R.L.; STROUD, L.; and RYGE, G.: Methods for Evaluating Prosthetic Facial Materials, *J Prosth Dent* 21:324-332, 1969.
2. WALTER, J.G.: A Material for Retentive Obturators, *Dent Practit* 20:208-212, 1970.
3. CHALIAN, V.A.; DRANE, J.B.; and STANDISH, S.M.: **Maxillofacial Prosthetics**, Baltimore: Williams and Wilkins Co., 1971, p. 283.
4. SWEENEY, W.T.; FISCHER, T.E.; CASTLEBERRY, D.J.; and COWPERTHWAITTE, G.F.: Evaluation of Improved Maxillofacial Prosthetic Materials, *J Prosth Dent* 27:296-305, 1972.
5. GOLDBERG, A.J.: Polyurethane Elastomers as Maxillofacial Prosthetic Materials, Dissertation, University of Michigan, Ann Arbor, 1977.
6. LEWIS, D.H.; COWSAR, D.R.; CASTLEBERRY, D. J.; and FISCHER, T.E.: New and Improved Elastomers for Extra-oral Maxillofacial Prostheses, *IADR Progr & Abst* 56: No. 174, 1977.
7. FINE, L.: Color and Its Application in Maxillofacial Prosthetics, *J Prosth Dent* 39:188-192, 1978.
8. FINE, L.; ROBINSON, J.E.; BARNHART, G.W.; and KARL, L.: New Method for Coloring Facial Prostheses, *J Prosth Dent* 39: 643-649, 1978.
9. CRAIG, R.G.; KORAN, A.; and YU, R.: Color Stability of Elastomers for Maxillofacial Appliances, *J Dent Res* 57:866-871, 1978.
10. YU, R.; KORAN, A.; and CRAIG, R.G.: Physical Properties of Elastomers for Maxillofacial Appliances Under Accelerated Aging, *AADR Progr & Abst* 56: No. 150, 1977.
11. KORAN, A.; YU, R.; POWERS, J.M.; and CRAIG, R.G.: Color Stability of Pigmented Elastomer for Maxillofacial Appliances, *J Dent Res* 58:1450-1454, 1979.
12. Annual Book of ASTM Standards, **Plastics - General Test Methods; Nomenclature**, Philadelphia, PA: American Society of Testing and Materials, 1977, p. 273.

13. JUDD, D.B. and WYSZECKI, G.: **Color in Business, Science and Industry**, New York: Wiley and Sons, Inc., 1975, p. 553.
14. GUENTHER, W.C.: **Analysis of Variance**, Englewood Cliffs, NJ: Prentice-Hall, 1964, p. 199.
15. DANNENBERG, E.M.: The Effects of Surface Chemical Interactions on the Properties of Filler-reinforced Rubber, *Rubber Chem and Tech* 48:410-444, 1975.
16. DEANIN, R.D. and SCHOTT, N.R.: **Fillers and Reinforcements for Plastics**, Washington, D.C.: American Chemical Society, 1974.
17. BILLMEYER, F.W.: **Textbook of Polymer Science**, 2nd edition, New York: John Wiley and Sons, Inc., 1971, p. 544
18. FLORY, P.J.: **Principles of Polymer Chemistry**, Ithaca, New York: Cornell University Press, 1953, p. 480.
19. FORDHAM, S.: **Silicones**, New York: Philosophical Library, Inc., 1961, p. 162.
20. NOLL, W.: **Chemistry and Technology of Silicones**, New York: Academic Press, 1968, p. 403.
21. YU, C.U. and MARK, J.E.: Specific Diluent Effects in Swollen Polymer Networks, *Macromolecules* 7:229, 1974.

ANNOUNCEMENT

American Pain Society, Second Annual Meeting, September 5-7, 1980, New York, N.Y.
For information write to:

Dr. W. Crawford Clark
Department of Psychiatry
Columbia University
722 West 168th Street
New York, N.Y. 10032