40. Wavelength Dependence of Stress in Glass Caused by Ultra-Violet Light

Stress in Glass Caused by Ultra-Violet Irradiation (Part 12)

By

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Stress is built up in borate and borosilicate glasses by ultra-violet light and a series of experiments were carried out by the authors to clarify the mechanisms of the phenomenon[1].

Experimental results indicated that the stress was a result of contraction of glass at a irradiated thin surface layer about 0.2 mm thick for commercial borosilicate glasses, and the value of the stress was considerably influenced by thermal history of glass or by impurity or a small amount of additional components in glass.

For the start of the process induced by light (or other electromagnetic waves), photon must be absorbed in material and the energy given or transfered to the reacting system must exceed a threshold value. The threshold value is considered to be a key to elucidate the mechanisms of the process.

The threshold photon energy for stress build-up was examined. Compositions of sample glasses are shown in Table 1. Transmission curves of thin plates of the glasses are given in Fig. 1. Prisms(15 × 10 × 5 mm) of the glasses were exposed to ultra-violet light. The source of ultra-violet light was a 400 W mercury discharge lamp made of fuzed silica glass(19 φ × 150 mm). Various kinds of glass filters were inserted between the lamp and sample prisms. The distances between the lamp and the filters and between the filters and the prisms were both 15mm. Prisms were examined photoelastically after irradiation for 1000 hrs.

Table 1. Composition of the glasses (wt%)

	SiO_2	Al_2O_3	B_2O_3	Na_2O	K_2O	Fe_2O_3	As_2O_3	Cl	Li_2O	BaO
Terex	80.42	2.44	12.65	3.80	0.41	0.065	0.20			
Kovar sealing glass	65.4	7.5	18.0	1.9	3.0		0.2		1.0	3.0
Pyrex*	80.55	2.25	12.94	4.20	0.01	0.026	0.025	0.043		

* Corning Glass Works

Preliminary experiment indicated that filters which completely absorbed light in the wavelength

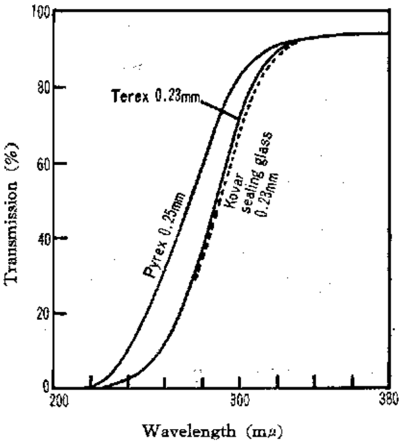

Fig. 1. Transmission curves of thin plates of the glasses

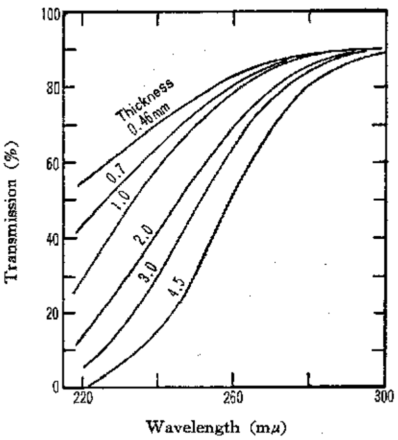

Fig. 2. Transmission curves of UV-25 filters with various thicknesses

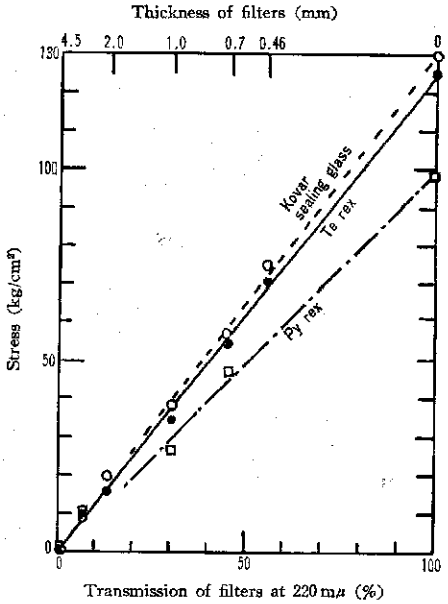

Fig. 3. Relation between stress and transmission of filters (at 220 mμ)

region less than 270 mμ prevented the stress from being built up. So, Toshiba UV-25 filters with various thicknesses were used. Transmission curves of the filters are given in Fig. 2.

The values of the stresses are plotted in Fig. 3 against the transmission at 220 mμ of the filters used. Apparently, proportionality between these quantities is good. It is, therefore, concluded that the stress in glass is caused by ultra-violet light with photon energy of 5.7 eV (220 mμ) or more. Fig. 1 indicates that the light in the wavelength region less than 220 mμ is completely absorbed in thin layers of the glasses. The above conclusion is compatible with the previous discussions by the authors that the process might be initiated by either excitation (the threshold energy is about 4.5 eV) or ionization (the threshold energy is about 5.5 eV) of non-bridging oxygen ions in glasses. Doping of some kinds of oxide might shift the threshold to longer wavelength region and sensitize the stress build-up[1a]. The effect is now under investigation.

References

1) K. Ōoka and T. Kishii, for example, a. *J. Ceram. Assoc. Japan* **72** [11-1] 193 (1964); b. *ibid.* **76** [1] 6 (1968); c. Preprint of The Annual Meeting of The Intern. Congress on Glass p. 259, Sept. (1966) Tokyo.

[Received March 5, 1968]

紫外線により発生するガラス中の応力の波長依存性

紫外線照射によるガラス中の応力発生（第12報）

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紫外線透過率がたがいに異なる数種のガラスフィルタを光源との間に入れて，3種の商用硼珪酸ガラスを紫外線で1,000時間照射した．照射された面に発生した応力は，使用したフィルタの 220 mμ における透過率とほぼ比例した．それゆえ，220 mμ あるいはそれ以下の短波長の光が応力を発生させると考えられる．この波長域の光は，厚さ 0.2 mm のガラスでほとんど吸収される．それゆえ，光子エネルギーを吸収することと，そのエネルギーがあるしきい値を超えることとが反応開始に必要であるという，光化学の基本原則はこの場合にも満たされている．また，220 mμ は 5.7 eV の光子エネルギーに相当するので，上記の実験結果は，応力発生過程は非架橋酸素イオンの励起（必要な最低エネルギーは 4.5 eV）またはイオン化（必要な最低エネルギーは 5.5 eV）から始まるという，著者らの提出した仮説とも適合している．

(3/5/1968 受付)