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Note

High-performance liquid chromatography of methyl methacrylate in intraocular lenses

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Aphakia of the human eye is usually corrected by the implantation of plastic lenses made of polymethyl methacrylate (PMMA)[1–3]. However, lenses pressed from this polymer may contain significant amounts of residual monomeric methyl methacrylate (MMA), and this has given rise to concern regarding possible deleterious effects on the anterior segment of the eye[4]. Because of depolymerization, the MMA content of the PMMA material may even increase during heat treatment, *e.g.*, during pressing in the manufacture of the lenses[4].

Analyses for the content of residual MMA in intraocular lenses have usually been carried out by gas–liquid chromatography (GLC). A recent publication[4] has prompted us to describe briefly our new high-performance liquid chromatography (HPLC) method for the analysis of MMA in intraocular lenses, which has been in use in this laboratory for some time. The HPLC method is of advantage because of its speed, simplicity and avoidance of high temperatures. The lens is simply weighed, dissolved in a suitable solvent and an aliquot of this solution is injected into the HPLC column. The MMA peak is quantitated against an external standard.

EXPERIMENTAL

For HPLC, individual lenses were weighed and dissolved at room temperature in 2 ml of ethyl acetate. A 10-μl sample of the solution was injected. A high-performance liquid chromatograph, consisting of a Milton Roy 196-100 pump (with pressure gauge, pulse-dampening coil and a silica pre-column), a Precision Sampling HPLC injector, a Waters Assoc. μPorasil separation column and a Schoeffel SF 770 variable-wavelength UV-detector, was used. The HPLC analyses were run in a solvent composed of hexane–diethyl ether (97:3). The MMA peak was detected at a UV wavelength of $\lambda = 220$ nm (0.1 a.u.f.s.) and quantitated *versus* external standards prepared by dissolving known amounts of pure MMA in ethyl acetate. A Hewlett-Packard HP 3354 computer was linked to the UV-detector. The pump-hub set at 10 units produced a flow-rate of 0.65 ml/min, at a column back-pressure of 50 bar. (In laboratories with higher ambient temperatures the hexane–diethyl ether mixture may be replaced by heptane–diisopropyl ether mixtures to avoid bubble formation in the pump.)

For GLC, the weighed lenses were dissolved in dimethylformamide (DMF) and their MMA content was determined by the headspace technique. For external standard calibration, solutions of known concentrations of MMA in DMF were prepared.

RESULTS AND DISCUSSION

Fig. 1 shows typical chromatograms obtained from individual lenses by HPLC. Lenses and lens material obtained from several different manufacturers showed MMA contents of between 0.3 and 4.7%. Fairly good agreement was found when HPLC and headspace-GLC (HS-GLC) results were compared directly for a number of lenses (Table I). The HPLC results tended to be slightly higher.

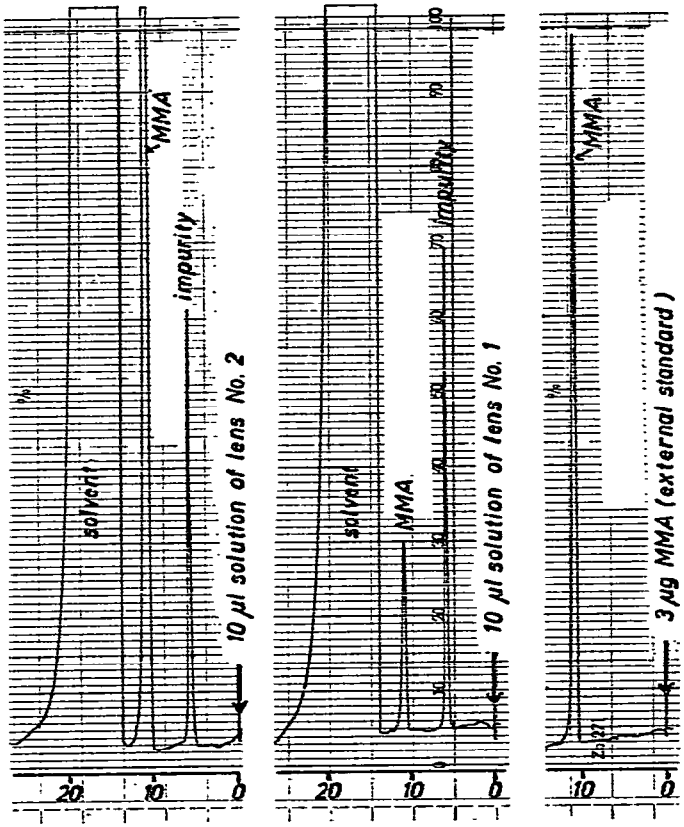

Fig. 1. HPLC of monomeric methyl methacrylate (MMA) in polymethyl methacrylate intraocular lens material. For conditions, see under Experimental.

As shown in Fig. 1, the HPLC analysis takes *ca.* 20 min. However, for routine analyses this can be shortened to <10 min by appropriate optimization of the solvent composition and flow-rate.

Depolymerization of PMMA may occur on hot metal surfaces, *e.g.*, in a GLC injector, when a solution of the polymer is injected. For this reason we preferred

TABLE I

MMA CONTENTS OF PMMA INTRAOCULAR LENSES AND LENS MATERIAL

Sample	*Date obtained*	*MMA (%)*	
		HPLC	*HS-GLC*
A	April 9	3.1	2.8
B	April 18	0.8, 0.8	0.7, 0.6
C	June 26	0.6, 0.5	0.5, 0.5
D	July 30	2.8	2.3, 2.5

to use an HS-GLC method rather than the direct injection of a solution of the polymer[4]. The preceding solution–headspace equilibrium should ensure that only the volatile monomer is present in the injected volume.

When a number of high values were observed, we nevertheless wanted to have an independent method of checking the HS-GLC results. HPLC presents an advantage in this respect because the whole analysis can be carried out at room temperature, in solution and with no risk of depolymerization. The agreement between values obtained by HPLC and HS-GLC showed that reliable results can be obtained by both methods.

Some manufacturers are still using an IR method[5] to determine MMA in PMMA. However, it is our opinion that this method is not adequate and should be replaced by either HS-GLC or HPLC. For non-destructive analysis (*e.g.*, of lenses to be implanted) Raman spectroscopy has been recommended[4].

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