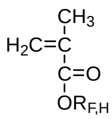
Fluoromonomers and Fluoropolymers - Fiber Optic Applications

Polymeric materials in general, and fluoropolymers in particular, are being extensively researched for their use in plastic optical fibers (POFs), waveguides, optical filters, fiber gratings, as well as other optical devices.[1-4] They offer several advantages over their inorganic counterparts including relative ease of processing, light weight, insensitivity to vibrational stress, low cost, and a wide versatility with respect to their design and synthesis to obtain properties that suit specific device parameters. In the case of POFs, fluoropolymers, which have the lowest refractive index, serve as cladding material to maximize the numerical aperture (NA) of the fiber. NA is a measure of the optical fiber's ability to trap light more efficiently and is quantified as NA = $[(n_{core}{}^2 - n_{cladding}{}^2)]^{1/2}$. Other issues that must be considered in the fabrication of POFs include transparency at the wavelengths of transmission, thermal expansion matching of cladding and core materials, and thermal stability in the temperature range of operation.

Fluoroalkyl Methacrylate Monomers

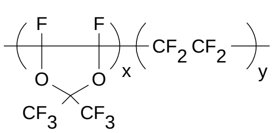


POFs based on specifically tailored fluoroalkyl methacrylate polymers have been reported.[3,5] The refractive index was controlled by adjusting the level of fluorination, copolymerization, or blending compositions to yield various core-cladding structures such as step index, single mode, or gradient index fibers with enhanced long-term stability. **Aldrich** offers a wide selection of these monomers; a **sampling** of these is highlighted below, along with the glass transition temperatures and refractive indices of the corresponding homopolymer, as reported in the literature.

Cat. No.	Monomer	$-R_{F,H}$	Unit Sizes	T_g †,‡ (°C)	n_D ‡,††
M5,590-9	Methyl methacrylate, 99%	$-CH_3$	500mL; 1L; 2L	105 [5,6]	1.489 [5]
37,376-1	2,2,2-Trifluoroethyl methacrylate, 99%	$-CH_2-CF_3$	5g 25g	69 [5,6]	1.418 [5] 1.490 [3,7]
37,199-8	2,2,3,3-Tetrafluoropropyl methacrylate, 99%	$-CH_2-CF_2-CHF_2$	5g 25g	68 [5,6]	1.417 [5] 1.422 [3]
47,419-3	2,2,3,3,3-Pentafluoropropyl methacrylate, 97%	$-CH_2-CF_2-CF_3$	5mL 25mL	70 [5] 77 [6]	1.1395 [5]
36,766-4	1,1,1,3,3,3-Hexafluoroiso-propyl methacrylate, 99%	$-CH(CF_3)_2$	1g 5g	56 [5]	1.390 [5]
37,197-1	2,2,3,4,4,4-Hexafluorobutyl methacrylate, 98%	$-CH_2-CHF-CF_2-CF_3$	5g 25g	–	–
44,400-6	2,2,3,3,4,4,4-Heptafluoro-butyl methacrylate, 97%	$-CH_2-CF_2-CF_2-CF_3$	1g 5g	65 [5]	1.383 [5]

† Glass transition temperature of the homopolymer. ‡ Literature references for the data are shown as superscripts. †† Refractive index of the homopolymer, at the sodium D line (λ_D = 5893Å).

Amorphous Fluoropolymers



Copolymers of PTFE and fluorinated dioxole have received widespread attention in the optoelectronics industry for their superior optical and dielectric properties. They are optically transparent due to the cycloether moieties in the structure which prevent crystallization. Also, their nonadhesive characteristics and low refractive index[8, 9] make them more interesting than PTFE for optical applications.

Cat. No.	Polymer	Unit Sizes	T_g (°C)	n_D
46,961-0	Poly[4,5-difluoro-2,2-bis(trifluoromethyl)-1,3-dioxole-*co*-tetrafluoroethylene], 65 mole % dioxole (Teflon® AF 1600)	1g	160	1.31
46,962-9	Poly[4,5-difluoro-2,2-bis(trifluoromethyl)-1,3-dioxole-*co*-tetrafluoroethylene], 87 mole % dioxole (Teflon® AF 2400)	1g	240	1.29

References: (1) ACS Symposium on Optical Polymers: Advances in Optical Fibers and Waveguides. In *Polymer Preprints*; American Chemical Society, Division of Polymer Chemistry: Washington, D.C., 1999; Vol. 40, p 1256. (2) Liang, J. et al. *Opt. Mater. (Amsterdam)* **1998**, *9*, 230. (3) van Duijnhoven, F.; Bastiaansen, C. *Adv. Mater*. **1999**, *11*, 567. (4) Guisheng, P. et al. *J. Am. Chem. Soc*. **1998**, *120*, 6518. (5) Gaynor, J. et al. *J. Appl. Polym. Sci*. **1993**, *50*, 1645. (6) Koizumi, S. et al. *Macromolecules* **1992**, *25*, 6563. (7) *Polymer Handbook*, 4th ed. Brandrup, J., Immergut, E., Grulk, E., Eds.; John Wiley & Sons, Inc.: Sommset, NJ, 1999; Aldrich Cat. No. **Z41,247-3**. (8) Legey, G. et al. *Eur. Polym. J*. **1998**, *34*, 1457. (9) Song, I. et al. *Appl. Spectrosc*. **1998**, *52*, 1364.