Stability to Ionising Radiation

Stability to γ-Rays

Perfluorocarbons (PFCs) have been tested for radiolytic stability, table 1. Their high thermal and chemical stability makes them obviously attractive to the nuclear industry. Up to 100ºC, these fluorocarbons showed reasonable stability (a G value or radiochemical yield of 1 to 4 molecules being destroyed per 100 eV of radiation applied). This is better than aliphatic hydrocarbons (cyclohexane gave a value of greater than six), but not as good as aromatic hydrocarbons (benzene 0.9, biphenyl 0.26). At higher temperatures, however, the PFCs come into their own, and at 450º still only 2 - 9 molecules are decomposing per 100 eV, while the hydrocarbons have broken down completely.

Reactions

γ-Induced reactions seem to be through carbon-carbon and carbon-fluorine bond cleavage, mostly the former, to produce radicals. These abstract other radicals or combine to form a number of products with higher and lower molecular weight than the starting material. No fluorine has been detected, and vessels have been reported as 'clean and bright' after irradiation. This might be because it forms but is quickly mopped up by any radicals present; however, the low fluorine-fluorine bond energy suggests formation will be minimal or non-existent. While high molecular weight compounds fragment, C4F8 tends to 'polymerise', i.e. give higher molecular weight materials. CF4 appears to be the most stable, but it could undergo numerous fragmentation-recombination reactions with no overall change.

Perfluorobicyclohexanyl (not produced by F2 Chemicals Ltd) seems to decompose readily under irradiation at higher temperature, presumably due to an efficient, long chain radical process. It is apparently unique among fluorocarbons in this respect (the effect has been used in the radiocracking of hydrocarbons by Esso) .

Other Radiation

Stability to electron beams has also been looked at, probably as a model to look at stability to γ-rays. Similar figures are obtained.

Table 1 *Stability of fluorocarbons to ionising radiation*

Compound	Dose/Mrad	Temperature/º	G/
γ-Rays			
Perfluorocyclobutane	78	450	4.6
Perfluorocyclohexane*	78	450	3.1
Perfluorodecalin (PP6)	78	450	6.3
Perfluoroperhydrophenanthrane (PP11)	78	450	8.6
Perfluoroperhydrofluoranthane	78	450	6.6
Perfluorobicyclohexyl*	0.33	450	>5000
Perfluorobiphenyl*	79	450	2.5
Perfluoronaphthalene*	80	450	4.8
Perfluoromethane*	67	25	1.1
Perfluoroethane*	36	25	4.0
Octafluoropropane (PP30)	143	25	3.7
Perfluoro-n-butane	134	25	3.8
Perfluoro-i-butane*	144	25	3.3
Perfluoro-n-pentane (PP50)	131	25	3.1
Perfluoro-n-hexane*	135	25	2.9
Perfluoro-2-methylpentane	145	25	2.7
Perfluoro-3-methylpentane*	146	25	2.6
Perfluoro-2,3-dimethylbutane*	45	25	5.0
Electron Beam			
Perfluorobenzene*	780	30	2.2
Perfluorobiphenyl*	770	105	1.4
Perfluoronaphthalene*	860	108	1.1
Perfluorocyclohexane*	620	90	2.4
Perfluorobicyclohexane*	890	122	1.6
Perfluorodecalin (PP6)	750	30	1.7

* Not a product offered by F2 Chemicals Ltd. but included for comparison.

Sources

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See also this presentation by CERN on the stability of perfluoro-2-methylpentane (PP1).

http://www.docstoc.com/docs/70112165/Characterization-of-the-initial-fluid

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