Table 21. Summary of the genotoxic effects of quartz in mammalian cells

	In vitro studies		In vivo studies	
Genotoxic effect	**Number of positive studies/number of studies available**	**Reference**	**Number of positive studies/number of studies available**	**Reference**
Sister chromatid exchange	1[*]/3	Price-Jones et al. [1980] Pairon et al. [1990] (2 experiments)	1[*]/1	Sobti and Bhardwaj [1991]
Chromosomal aberrations	0/3	Nagalakshmi et al. [1995] (2 experiments) Oshimura et al. [1984]	1[*]/1	Sobti and Bhardwaj [1991]
Micronuclei	3/4	Oshimura et al. [1984] Hesterberg et al. [1986] Nagalakshmi et al. [1995] (2 experiments)[†]	0/1	Vanchugova et al. [1985]
Aneuploidy or tetraploidy	0/3	Price-Jones et al. [1980]; Oshimura et al. [1984]; Hesterberg et al. [1986]	0/0	
hprt mutation[‡]	0/1	Driscoll et al. [1997]	2/2[§]	Driscoll et al. [1995, 1997]

Source: IARC [1997].

[*]One questionably positive study available.

[†]One experiment by Nagalakshmi et al. [1995] showed an increase in the frequency of micronucleated cells at all concentrations tested, but the increase was statistically significant ($P<0.05$) only at the two highest concentrations tested.

[‡]*hprt* = hypoxanthine-guanine phosphoribosyl transferase.

[§]Mutagenic response associated with inflammation.

Table 22. Summary of data on lung tumors induced in rats by crystalline silica

Sample and exposure conditions	Rat strain	Sex	Incidence of lung tumors[*]		Reference	Comments
			Treated rats	Controls		
Quartz (Min-U-Sil 5):						
Intratracheal instillation of 7 mg/wk for 10 wk	Sprague-Dawley	—[†]	6/36	0/58	Holland et al. [1983]	Treated rats had 1 adenoma and 5 carcinomas.
Inhalation (nose only) of 12 ± 5 mg/m^3 for up to 2 yr	Fischer 344	F	20/60	0/54	Holland et al. [1986]	Treated rats had 6 adenomas, 11 adenocarcinomas, and 3 epidermoid carcinomas.
Inhalation of 51.6 mg/m^3 for various durations; sacrificed at 24 months	Fischer 344	F M	10/53 1/47	0/47 0/42	Dagle et al. [1986]	Treated female rats had 10 epidermoid carcinomas. Treated male rats had 1 epidermoid carcinoma.
Intratracheal instillation of 20 mg in left lung; sacrificed at 12, 18, or 22 months, or found dead	Fischer 344	M	30/67	1/75	Groth et al. [1986]	Treated rats had 30 adenocarcinomas. Controls had 1 adenocarcinoma.
Novaculite (i.e., microcrystalline quartz):						
Intratracheal instillation of 20 mg in left lung; sacrificed at 12, 18, or 22 months, or found dead	Fischer 344	M	21/72	1/75	Groth et al. [1986]	Treated rats had 20 adenocarcinomas and 1 epidermoid carcinoma. Controls had 1 adenocarcinoma.
Raw shale dust:						
Inhalation (nose only) of 152 ± 51 mg/m^3 (average quartz content: 8%–12%)	Fischer 344	F	17/59	0/54 1/15[‡]	Holland et al. [1986]	Treated rats had 2 adenomas, 8 adenocarcinomas, and 7 epidermoid carcinomas. Controls had 1 adenoma.

Table 22 (Continued). Summary of data on lung tumors induced in rats by crystalline silica

Sample and exposure conditions	Rat strain	Sex	Incidence of lung tumors*		Reference	Comments
			Treated rats	Controls		
Spent shale dust:						
Inhalation (nose only) of 176 ± 75 mg/m^3 (average quartz content: 8%–12%)	Fischer 344	F	11/59	0/54 1/15‡	Holland et al. [1986]	Treated rats had 2 adenomas, 8 adenocarcinomas, and 1 epidermoid carcinoma. Controls had 1 adenoma.
Quartz (DQ12):						
Inhalation of 1 mg/m^3 for 24 months	Fischer 344	F	12/50	3/100 (male and female)	Muhle et al. [1989]	Treated female rats had 2 keratinizing cystic squamous cell tumors, 2 adenomas, and 8 adenocarcinomas. Treated male rats had 2 keratinizing cystic squamous cell tumors, 2 adenocarcinomas, 1 adenosquamous carcinoma, and 1 squamous cell carcinoma. Controls had 2 adenomas and 1 adenocarcinoma.
	Fischer 344	M	6/50	—		
Inhalation (nose only) of 6 mg/m^3 for 29 days followed by lifetime observation	Wistar	F	62/82	0/85	Spiethoff et al. [1992]	Treated rats had 8 adenomas, 17 bronchioloalveolar carcinomas, and 37 squamous cell carcinomas.
Inhalation (nose only) of 30 mg/m^3 for 29 days followed by lifetime observation	Wistar	F	69/82	0/85	Spiethoff et al. [1992]	Treated rats had 13 adenomas, 26 bronchioloalveolar carcinomas, and 30 squamous cell carcinomas.

Source: Adapted from Saffiotti et al. [1996].
*Number of lung tumors per number of rats observed.
†Not reported.
‡Investigators used two control groups.

See footnotes at end of table.

(Continued)

Table 23. Lung tumors induced in Fischer 344 rats by a single intratracheal instillation of quartz

Treatment sample and dose[*]	Sex	Observation time	Incidence of lung tumors		Total number of lung tumors[‡]	Histological types
			Number[†]	%		
Untreated:						
No dose	M	Died after 17 months	0/32	—	0	—
No dose	F	Died after 17 months	1/20	5	1	1 adenoma
Quartz (Min-U-Sil 5):						
12-mg dose	M	Sacrificed at 11 months	3/18	17	37	6 adenomas, 25 adenocarcinomas, 1 undifferentiated carcinoma, 2 mixed carcinomas, and 3 epidermoid carcinomas
		Sacrificed at 17 months	6/19	32		
		Died after 17 months	12/14	86		
12-mg dose	F	Sacrificed at 11 months	8/19	42	59	2 adenomas, 46 adenocarcinomas, 3 undifferentiated carcinomas, 5 mixed carcinomas, and 3 epidermoid carcinomas
		Sacrificed at 17 months	10/17	59		
		Died after 17 months	8/9	89		
20-mg dose	F	Died after 17 months	6/8	75	13	1 adenoma, 10 adenocarcinomas, 1 mixed carcinoma, and 1 epidermoid carcinoma
Quartz (hydrogen fluoride-etched Min-U-Sil 5):						
12-mg dose	M	Sacrificed at 11 months	2/18	11	20	5 adenomas, 14 adenocarcinomas, and 1 mixed carcinoma
		Sacrificed at 17 months	7/19	37		
		Died after 17 months	7/9	78		
12-mg dose	F	Sacrificed at 11 months	7/18	39	45	1 adenoma, 36 adenocarcinomas, 3 mixed carcinomas, and 5 epidermoid carcinomas
		Sacrificed at 17 months	13/16	81		
		Died after 17 months	8/8	100		

Sources: Saffiotti et al. [1993; 1996].
[*]As mg quartz suspended in 0.3 ml saline.
[†]Number of rats with lung tumors per number of rats observed.
[‡]At all observation times.

See footnotes at end of table.

(Continued)