

**ROBUST SUMMARY
OF INFORMATION ON**

Substance Group

PETROLEUM COKE

Summary prepared by

American Petroleum Institute

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NB. Reliability of data included in this summary has been assessed using the approach described by Klimisch et al.

Klimisch, H. J., Andreae, M. and Tillman, U, (1997)

A systematic approach for evaluating the quality of experimental toxicological and ecotoxicological data.

Regulatory Toxicology and Pharmacology 25, 1-5.

1. General Information

1.1 General Substance Information

Substance type: Petroleum product
Physical status: Solid

Petroleum coke is a black solid produced by the thermal decomposition of petroleum fractions. It may be one of two basic types viz. GREEN petroleum coke (CAS # 64741-79-3) or CALCINED petroleum coke (CAS # 64743-05-1).

GREEN coke can be prepared by different processes and as a consequence may be described as either delayed process coke, fluid process coke or flexicoke.

GREEN Coke may contain up to 15% residual hydrocarbon.

CALCINED coke is produced by heating green coke to temperatures up to 1200°C. The resulting material consists essentially of carbon and contains virtually no hydrocarbon.

With one exception, all the studies summarised in this document have been conducted on GREEN coke. It is envisaged that because of the essential difference between GREEN and CALCINED coke (ie a higher hydrocarbon content) the results from the studies on GREEN coke represent a worst case situation and that CALCINED coke would be no more toxic than the GREEN coke samples that have been examined.

1.2 Synonyms

Green coke
Calcined coke
Delayed process coke
Flexicoke
Fluid process coke

2. Physico-chemical data

2.1 Melting Point

Not relevant

2.2 Boiling Point

Not relevant

2.3 Density**Type:**

Bulk density

Value:0.7 - 0.95 g/cm³**Remark:**

Data summarised by CONCAWE for Green and Calcined coke are as follows:

	<u>Green coke</u>	<u>Calcined coke</u>
Bulk density (kg/dm ³)	0.7 - 0.9	0.75 - 0.95
Real density (kg/dm ³)	1.35 - 1.45	2.06 - 2.16

Reliability:

4, not assignable, - source of original data unknown. However, information may be useful as a guide.

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2.3.1 Granulometry

Not relevant

2.4 Vapour Pressure

Not relevant

2.5 Partition Coefficient

Not relevant

2.6.1 Water Solubility

Insoluble

2.6.2 Surface Tension

Not relevant

2.7 Flash Point

Not relevant

2.8 Auto Flammability

Not relevant

2.9 Flammability

Not relevant

2. Physico-chemical data

2.11 Oxidizing Properties

Not relevant

3. Environmental Fate and Pathways

3.1.1 Photodegradation

Not relevant

3.1.2 Stability in Water

Petroleum coke is an insoluble solid, consisting essentially of carbon.

3.1.3 Stability in Soil

Stable

3.4 Mode of Degradation in Actual Use

Not relevant

3.5 Biodegradation

Not biodegradable

3.6 BOD5, COD or BOD5/COD Ratio

Not relevant

5. Toxicity

5.1 Acute Toxicity

5.1.2 Acute Inhalation Toxicity

Species: Rat
Sex: Male/female
Number of Animals: 300
Vehicle: Air as diluent
Exposure time: 6 hour(s)
Value: > 30.7 mg/l
Year: 1981
GLP: Yes
Test substance: Green petroleum coke (CAS # 64741-79-3)
 Calcined petroleum coke (CAS # 64743-05-1)
Remark: No studies have been carried out to determine the acute inhalation LC₅₀ for petroleum coke following a single exposure. However, longer-term repeat-dose studies have been carried out and a full description of these is given in Section 5.4. In these studies, doses causing no effect after a 6 hour exposure to petroleum coke can be determined; they are as follows:

Species	LC ₅₀	Ref.
Rat	>30.7 mg/m ³	IRDC (1985)
Monkey	>30.7 mg/m ³	IRDC (1985)
Rat*	>50.0 mg/m ³	Huntingdon Life Sciences (1999)

* This experiment applies to green and calcined coke.

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5.4 Repeated Dose Toxicity

Species: Rat
Sex: Male/female
Strain: Sprague-Dawley
Route of administration: Inhalation
Exposure period: 2 Years
Frequency of treatment: 6 hours/day, 5 days/week for 2 years (except holidays)
Post. observation. period: None
Doses: 10.2 and 30.7 mg/m³
Control Group: Yes, concurrent no treatment
LOAEL: 10.7 mg/m³
Year: 1981
GLP: No

Test substance: Green petroleum coke (Delayed process, micronized), CAS # 64741-79-3.
 There was a stable particle size distribution of 3.1 microns over the duration of the study.
 A full analysis of the coke sample (approximately 90% carbon) was undertaken at the beginning and at the end of the study. The results showed that there had been no change in the sample. A complete analysis is provided in the report.

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Method:

Groups of 150 male and 150 female rats underwent whole body exposures to the powdered test materials at concentrations of 10.2 and 30.7 mg/m³ for 6 hours daily, 5 days a week for 2 years (holidays excepted).

A group of 150 rats of each sex served as untreated controls.

Chamber concentrations were confirmed daily by means of a gravimetric sampling procedure.

Animals were observed twice daily for mortality, weekly for a fuller clinical examination and body weights were also recorded weekly. 10 male and 10 female rats underwent ophthalmologic examination after 3, 6, 12, 18 and 24 months of exposure.

Baseline clinical laboratory determinations were made prior to the exposures on 10 rats of each sex from each group. Clinical chemical and haematological evaluations were undertaken on 10 rats of each sex after 1, 3, 6, 12, 18 and 24 months exposure.

All rats dying or sacrificed in extremis were necropsied. Scheduled interim sacrifices were made as follows: 10/sex/group after 5 days and 1 month's exposure; 20/sex/group after 3, 6 and 12 months exposure; 10/sex/group after 18 months exposure. All survivors at 24 months were necropsied. Weights of major organs were recorded at necropsy and a wide range of tissues examined histologically.

A complete cytogenetics evaluation was undertaken on 10 rats of each sex after 5 days and 12 months exposure. Slide preparations were also made for cytogenetic evaluations on 10 rats of each sex after 1, 3 and 6 months exposure. After approximately 22½ months 5-9 rats/sex/group were evaluated. All data were evaluated using appropriate statistical analyses.

Result:

There were no treatment-related effects with respect to clinical condition, growth rates, ophthalmological findings, or serum biochemistry. Furthermore, the cytogenetic evaluations did not differ from those for control animals. Although there were statistically significant differences with respect to segmented neutrophils and lymphocytes between treated and control rats, these were not consistent throughout the study. It was concluded that these changes were probably indicative of a mild inflammatory reaction as a result of deposition of test material in the lungs.

There were significant dose related increases in absolute and relative lung plus trachea weights in the 30.7mg/m³ group when compared to controls. The effects were noted after 3 months exposure for females and 6 months exposure for males. In the low dose group the effects were seen in females after 18 months and in males after 24 months exposure.

At necropsy it was noted that the exposed rats had gray/black discolouration and foci of the lung and black thoracic lymph nodes at all measurement periods and at termination. Lung masses or nodules were observed at the 18 month and 24 month sacrifice and in rats dying spontaneously or sacrificed in extremis between 18 and 24 months. These masses or nodules corresponded to the

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microscopic findings of keratin cysts.

Histological examination showed that chronic pulmonary inflammation had occurred at the 3, 6, 12 and 18 month intervals. Pulmonary sclerosis, squamous alveolar metaplasia and a keratin cyst were first observed in rats at the 18 month sacrifice and the incidence of these findings increased during the last 6 months of the study.

Overall, the microscopic changes observed increased in severity with increasing exposure concentration and increasing duration of exposure.

This result is undoubtedly due to deposition of test material and the occurrence of an inflammatory response in the lung which was reflected in an increased lung weight.

Other than changes in the lung, there were no other significant treatment related changes and there was no evidence of a carcinogenic response to exposure to petroleum coke.

Remark:

Note that the results of the cytogenetic evaluations are also reported in section 5.6.

Reliability:

1, valid without restriction. This is a well documented study. All raw data are available for further evaluation if required. Although the study was not conducted according to GLP, there were thorough quality assurance reviews for all segments of the study.

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5. Toxicity

Species:	Rat
Sex:	Male
Strain:	Fischer 344
Route of administration:	Inhalation
Exposure period:	6 hours per day for 5 days
Frequency of treatment:	Daily for 5 days
Post. Observation period:	63 days
Doses:	50 mg/m ³
Control Group:	Yes
NOAEL:	> 50 mg/m ³
Test substance:	Green petroleum coke (CAS # 64741-79-3), 100% pure Calcined petroleum coke (CAS # 64743-05-1), 99.5% pure
Year:	1999
GLP:	Yes
Test condition:	The test materials were delivered as dusts to the 40 litre nose-only inhalation chambers at nominal concentrations of 50 mg/m ³ . The control materials titanium dioxide (negative control) and silicon dioxide (positive control) were also delivered as dusts at nominal concentrations of 50 mg/m ³ . The actual mass median aerodynamic diameters for the particles of test and control materials was determined and were as follows: Titanium dioxide 0.9433 µm Silicon dioxide 1.737 µm Green coke 2.712 µm Calcined coke 2.692 µm Chamber concentrations were monitored and found to be: Titanium dioxide 53.2 mg/m ³ Silicon dioxide 51.0 mg/m ³ Calcined coke 45.0 mg/m ³ Green coke 58.2 mg/m ³
Method:	Groups of 40 male rats were exposed to either titanium dioxide, silicon dioxide, green coke or calcined coke, each at a nominal concentration of 50 mg/m ³ . The nose-only exposures were for 6 hours each day for 5 consecutive days. 10 animals from each group were sacrificed 7, 28 and 63 days after the last exposure. Clinical examination was undertaken throughout the study and body weights were recorded twice pre-test, once during exposure and weekly thereafter. At sacrifice bronchoalveolar lavage was performed and a biochemical and cytological examination was made on the lavage fluid. An extra 10 rats from each group were sacrificed 63 days post exposure. For these animals brain and lung weights were recorded and a complete macroscopic post mortem examination was undertaken. A histopathological examination of the lungs was also made for these extra animals.
Result:	There were no mortalities during the study and there were no significant exposure-related clinical findings, apart from a slight discolouration of the fur of those animals exposed to coke and a slight increase in incidence of chromodacryorrhea in all groups except the TiO ₂ group. Apart from marginal weight loss which occurred during the exposure period only, no significant effect on growth rates were observed for any treatment group in the study.

At the day 7 and day 28 interval, analysis of the bronchiolar lavage

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fluid did not give any indication of pulmonary toxicity. However, at the day 63 interval a pulmonary effect was noted in the SiO₂ animals and to a lesser degree in the coke exposed animals. The effects in the coke-exposed animals were considered to be a 'slight effect'. The changes noted were: an increase in n-acetylglucosamidase, total protein, total cell count, neutrophil and lymphocyte count.

At 63 days, lung weights of those animals exposed to coke were considered to be comparable with those of both control groups. Although red discolouration of the lungs and parabranchial lymph nodes of the coke-exposed animals was observed this was not regarded as being of toxicological significance. Some inflammation was observed in all treatment groups. The increasing severity of the inflammation was in the order: TiO₂, calcined coke, green coke and SiO₂, the latter being the most severe.

Overall, it was concluded that neither calcined nor green coke caused a fibrogenic effect in the lungs when compared to silicon dioxide and titanium dioxide. Although some pulmonary inflammation occurred, it was less severe than that caused by silicon dioxide, and more severe than that caused by titanium dioxide. Inflammation was slightly greater in the green coke when compared to the calcined coke.

Reliability:

1, valid without restriction.

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5. Toxicity

Species:	Primate
Sex:	Male/female
Strain:	Macaca Fascicularis
Route of administration:	Inhalation
Exposure period:	24 Months
Frequency of treatment:	6 hours/day, 5days/week for 24 months (excluding holidays)
Post. observation period:	None
Doses:	10.2 and 30.7 mg/m ³
Control Group:	Yes, concurrent no treatment
Method:	2-year primate inhalation study
Year:	1981
GLP:	No
Test substance:	Green petroleum coke (Delayed process, micronized), CAS # 64741-79-3 There was a stable particle size distribution over the duration of the study of 3.1 microns. A full analysis of the coke sample (approximately 90% carbon) was undertaken at the beginning and at the end of the study. The results showed that there had been no change in the sample over the period of the study. A complete analysis is provided in the report.
Method:	Groups of 4 male and 4 female mature, adult monkeys underwent whole body exposures to the powdered test materials at concentrations of 10.2 and 30.7 mg/m ³ for 6 hours daily, 5 days a week for 2 years (holidays excepted). A group of 4 monkeys of each sex served as untreated controls. Chamber concentrations were confirmed daily by means of a gravimetric sampling procedure. Animals were observed twice daily for mortality, monthly for a fuller clinical examination and body weights were also recorded monthly. Ophthalmologic examinations were conducted on all monkeys prior to exposure and after 1, 3, 6, 12 18 and 24 months of exposure. Baseline clinical laboratory determinations were made twice prior to the exposures on all monkeys. Clinical chemical and haematological evaluations were undertaken on all monkeys after 1, 3, 6, 12, 18 and 24 months exposure. All survivors at 24 months were necropsied. Weights of major organs were recorded at necropsy and a wide range of tissues examined histologically. After 24 months exposure all monkeys were evaluated for calcium and phosphorus levels in bone ash, using samples from femur and rib. All data were evaluated using appropriate statistical analyses.
Result:	There were no treatment related effects with respect to clinical condition, growth rates, ophthalmological findings, serum biochemistry or haematological parameters. There were significant dose related increases in absolute and relative lung plus trachea weights in both dose groups of male and females after 24 months exposure. At necropsy it was noted that the exposed monkeys had gray/black discolouration and foci of the lung and black thoracic lymph nodes. Histological examination showed trace to moderate

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accumulations of alveolar macrophages containing test material in both sexes and at both dose levels. Similar accumulations of macrophages were also seen in the thoracic lymph nodes and in paratracheal lymphoid tissue. There were no other significant treatment related changes.

Reliability: 1, valid without restriction. This is a well documented study. All raw data are available for further evaluation if required. Although the study was not conducted according to GLP, there were thorough quality assurance reviews for all segments of the study.

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5.5 Genetic Toxicity 'in Vitro'

Type: Ames test
System of testing: Assays carried out using *S. typhimurium* strains TA 1535, TA 1537, TA 1538, TA 98 and TA 100
Concentration: 5 concentrations: up to 10,000µg/0.1ml
Metabolic activation: With and without
Result: Negative
Method: OECD Guide-line 471 "Genetic Toxicology: Salmonella typhimurium Reverse Mutation Assay"
Year: 1979
GLP: No data
Test substance: Green petroleum coke (Delayed process, micronized)
 CAS # 64741-79-3
 Sample 4-1-140.
 Black powder.
 An analysis of the sample has been conducted and reported elsewhere (Gulf R&D Co. Report No. 553RL069)
 Solvent used: DMSO
 Concentrations for toxicity testing:
 1,000; 100; 10; 1.0 and 0.1µg/ml
 Concentrations for mutagenicity testing were:
 123.5; 370.4; 1111.1; 3333.3 and 10,000µg/0.1ml

Method: An S9 mammalian liver cell fraction was obtained from Sprague Dawley rats that had been induced with Aroclor® 1254 at a dose of 500mg/Kg i.p. for 5 days. 0.5ml of the S9 fraction was used in the Ames assays. The assay was also run using a negative, solvent (DMSO) control and a positive control.

Result: Although the highest concentration tested (10,000µg/0.1 ml) did not show bacterial growth inhibition, the limits of solubility of the test material had clearly been reached. Using the 5 Salmonella typhimurium strains, the delayed process coke sample was not mutagenic at any of the concentrations tested either with or without metabolic activation.

Reliability: 1, valid without restriction. Although this study was probably not conducted to GLP the test parameters were based on a well established procedure and was conducted by a well established laboratory. The report describes fully the procedures used and the results obtained.

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5. Toxicity

Type:	Ames test
System of testing:	Assays carried out using <i>S. typhimurium</i> strains TA 1535, TA 1537, TA 1538, TA 98 and TA 100
Concentration:	5 concentrations: up to 10,000µg/0.1ml
Metabolic activation:	With and without
Result:	Negative
Method:	OECD Guide-line 471 "Genetic Toxicology: Salmonella typhimurium Reverse Mutation Assay"
Year:	1979
GLP:	No data
Test substance:	Green coke (Fluid process) CAS # 64741-79-3 Sample 6-1-468. Black powder. An analysis of the sample has been conducted and reported elsewhere (Gulf R&D Co. Report No. 553RL069) Solvent used: DMSO Concentrations for toxicity testing: 1,000; 100; 10; 1.0 and 0.1µg/ml Concentrations for mutagenicity testing were: 123.5; 370.4; 1111.1; 3333.3 and 10,000µg/0.1ml.
Method:	An S9 mammalian liver cell fraction was obtained from Sprague Dawley rats that had been induced with Aroclor® 1254 at a dose of 500mg/Kg i.p. for 5 days. 0.5ml of the S9 fraction was used in the Ames assays. The assay was also run using a negative, solvent (DMSO) control and a positive control.
Result:	Heavy chemical precipitation occurred at the three highest concentrations tested which meant manual counting of the number of revertant colonies at these levels. At the highest concentration (10,000µg/0.1ml) the revertant colonies of TA1538, TA98 and TA100 could not be counted due to a heavy bacterial contamination. However, no mutagenic activity was found at any of the other concentrations tested for any of the Salmonella strains either with or without metabolic activation. In conclusion, the sample of fluid process coke was not mutagenic in the assay.
Reliability:	2, valid with restrictions. Although the study was partially compromised due to bacterial contamination, it was nevertheless reported fully and raw data are available in the report for evaluation. The results are consistent with those from other studies on similar materials.

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5. Toxicity

Type:	Mouse lymphoma assay
System of testing:	Assay carried out using L5417 mouse lymphoma cell line
Concentration:	8 concentrations up to 2000 µg/ml
Metabolic activation:	With and without
Result:	Negative
Method:	OECD Guide-line 476 "Genetic Toxicology: In vitro Mammalian Cell Gene Mutation Tests"
Year:	1979
GLP:	No data
Test substance:	Green coke (Delayed process) CAS # 64741-79-3 Sample 4-1-140. Black powder. An analysis of the sample has been conducted and reported elsewhere (Gulf R&D Co. Report No. 553RL069). Solvent used: DMSO Concentrations for toxicity testing: 5; 1,000; 10,000; 50,000 and 100,000 µg/ml Concentrations for mutagenicity testing were: 600; 800; 1,000; 1,200; 1,400; 1,600; 1,800 and 2,000 µg/ml Positive control substance: ethyl methane sulphonate not requiring activation, Promitogen requiring S 9 activation.
Method:	The study was conducted according to guideline. S-9 cofactor was obtained from Sprague Dawley rats that had been induced with PCBs.
Result:	No toxicity to mouse lymphoma cells was observed at concentrations up to 2000µg/ml. Insolubility of test compound precluded testing at higher concentrations. The values for spontaneous and induced mutation frequencies were within acceptable limits. The petroleum coke sample 4-1-140 did not induce forward mutations at the thymidine kinase (TK) locus in L5178Y, clone 3.7.2, Mouse Lymphoma cells either with or without metabolic activation.
Reliability:	1, valid without restriction.

(2, 3)

5. Toxicity

Type:	Mouse lymphoma assay
System of testing:	Assay carried out using L5417 mouse lymphoma cell line
Concentration:	8 concentrations up to 2,000 µg/ml
Metabolic activation:	With and without
Result:	Negative
Method:	OECD Guide-line 476 "Genetic Toxicology: In vitro Mammalian Cell Gene Mutation Tests"
Year:	1979
GLP:	No data
Test substance:	Green coke (Fluid process) CAS # 64741-79-3 Sample 6-1-468. Black powder. An analysis of the sample has been conducted and reported elsewhere (Gulf R&D Co. Report No. 553RL069). Solvent used: DMSO Concentrations for toxicity testing: 5; 1,000; 10,000; 50,000 and 100,000 µg/ml Concentrations for mutagenicity testing were: 600; 800; 1,000; 1,200; 1,400; 1,600; 1,800 and 2,000 µg/ml Positive control substance: ethyl methane sulphonate not requiring activation, Promitogen requiring S 9 activation.
Method:	The study was conducted according to guideline. S 9 cofactor was obtained from Sprague Dawley rats that had been induced with PCBs.
Result:	No toxicity to mouse lymphoma cells was observed at concentrations up to 2000µg/ml. Insolubility of test compound precluded testing at higher concentrations. The mutation frequencies for the positive controls were within acceptable limits. The spontaneous mutation frequency (2.6) for the solvent controls without metabolic activation was lower than generally seen for DMSO. However, this lower frequency was attributed to an unusually high cell count for the non-selective count and it was concluded that this had probably been caused by a dilution error. The spontaneous background mutational frequency for the media (5.5) was comparable to previous results obtained in the laboratory. Therefore, the media control mutation frequency (5.5) rather than that for the solvent (2.6) was used to evaluate the non-activated portion of the assay. This approach is further supported by the fact that there were no significant increases in the number of TK-/- mutant colonies on the selective medium plates from the test doses as compared to the solvent control. In conclusion, the petroleum coke sample 6-1-468 did not demonstrate a positive response and is not mutagenic in the L5178Y Mouse Lymphoma assay, either with or without metabolic activation.
Reliability:	2, valid with restrictions. A possible dilution error may have compromised the results for the negative controls. However, the overall result of the assay is in-line with similar assays on similar materials. Furthermore the error gives conclusions that are more conservative than would be otherwise expected had the negative control values been greater.

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5.6 Genetic Toxicity 'in Vivo'

Type:	2 year inhalation study
Species:	Rat
Sex:	Male/female
Strain:	Sprague-Dawley
Route of administration:	Inhalation
Exposure period:	Up to 2 years
Doses:	10.2 and 30.7 mg/m ³
Result:	Negative
Year:	1981
GLP:	Yes
Test substance:	Green petroleum coke (Delayed process, micronized). CAS # 64741-79-3 There was a stable particle size distribution of 3.1 microns over the duration of the study. A full analysis of the coke sample (approximately 90% carbon) was undertaken at the beginning and at the end of the study. The results showed that there had been no change in the sample. A complete analysis is provided in the report.
Method:	Groups of 150 male and 150 female rats underwent whole body exposures to the powdered test materials at concentrations of 10.2 and 30.7 mg/m ³ for 6 hours daily, 5 days a week for 2 years (holidays excepted). A group of 150 rats of each sex served as untreated controls. Chamber concentrations were confirmed daily by means of a gravimetric sampling procedure. Animals were observed twice daily for mortality, weekly for a fuller clinical examination and body weights were also recorded weekly. A complete cytogenetics evaluation was undertaken on bone marrow smears taken from 10 rats of each sex after 5 days and 12 months exposure. Slide preparations of bone marrow were also made for cytogenetic evaluations (examination for evidence of chromosomal aberrations) on 10 rats of each sex after 1, 3 and 6 months exposure. After approximately 22½ months 5-9 rats/sex/group were evaluated. All data were evaluated using appropriate statistical analyses.
Remark:	This study was made on an extra group of rats that had been included in a two year inhalation study with green coke. (See section 5.4.).
Result:	Although there were statistically significant differences with respect to segmented neutrophils and lymphocytes between treated and control rats, these were not consistent throughout the study. It was concluded that these changes were probably indicative of a mild inflammatory reaction as a result of deposition of test material in the lungs. Overall, the results of the cytogenetic evaluations of the bone marrow did not differ from those for control.
Reliability:	1, valid without restriction.

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Type:	Cytogenetic assay
Species:	Rat
Sex:	Male
Strain:	Sprague-Dawley
Route of administration:	Inhalation
Exposure period:	28 days
Doses:	0, 12.45 and 45.34 µg/l
Year:	1979
GLP:	No data
Test substance:	Green coke (Delayed process) CAS # 64741-79-3 Sample 4-1-100. Black powder. An analysis of the sample has been conducted and reported elsewhere (Gulf R&D Co. Report No. 553RL069). Dust atmosphere generated using a cascade impactor to achieve particles < 5µ.
Method:	Groups of 8 sexually mature male Sprague Dawley rats were exposed to powdered coke sample at the following nominal concentrations: 0, 10 and 40µg/l. The low dose animals were exposed 6 hours each day, 5 days per week for 20 exposures. The high dose animals were exposed 6 hours each day for 5 days only. Controls were held for the same time as the low dose group animals. The day after each animal's last exposure colchicine was administered to inhibit mitosis. Two hours later the animals were sacrificed and bone marrow smears were made from the femur. The slides were photographed for a permanent record.
Result:	Gravimetric samples collected throughout the study established the actual exposure concentrations to be 0, 12.45 and 45.34 µg/l. Appearance, behaviour and growth rates were unaffected by exposure. There was some deposition of test material on the fur of the animals exposed to the coke sample. There were no significant differences among any of the groups when comparing the percentages of cells containing chromosome breaks or severely damaged cells. There was however a significant increase in the number of chromatid breaks, markers and total aberrations in the highest dose group when compared to controls. Mitotic indices were unaffected by exposure to petroleum coke. In conclusion, petroleum coke sample 4-1-100 produced structural mutations in bone marrow cells of rats exposed to 45.34 µg/l by inhalation for 5 consecutive days. No effects were noted at the lower dose level tested over a period of 20 exposures.
Reliability:	3, invalid. The study result was re-evaluated and the investigator showed that slides had been read inconsistently and misread in some cases. The investigator considered the study invalid for the purpose of assessing clastogenic potential.

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Type:	Cytogenetic assay
Species:	Rat
Sex:	Male
Strain:	Sprague-Dawley
Route of administration:	Inhalation
Exposure period:	28 days
Doses:	0, 10 and 40 µg/l
Result:	Negative
Year:	1979
GLP:	No data
Test substance:	Green coke (Fluid process) CAS # 64741-79-3 Sample 6-1-648. Black powder. An analysis of the sample has been conducted and reported elsewhere (Gulf R&D Co. Report No. 553RL069). Test atmosphere generated using a wright dust feed mechanism. The atmospheres consisted of particles < 5µ. Test atmosphere concentrations were 0, 10 and 40 µg/l.
Method:	Groups of 8 sexually mature male Sprague Dawley rats were exposed to the powdered coke sample at the following nominal concentrations: 0, 10 and 40µg/l. The low dose animals were exposed 6 hours each day, 5 days per week for 20 exposures. The high dose animals were exposed 6 hours each day for 5 days only. Controls were held for the same time as the low dose group animals. The day after each animal's last exposure colchicine was administered to inhibit mitosis. Two hours later the animals were sacrificed and bone marrow smears were made from the femur. The slides were photographed for a permanent record.
Result:	Appearance, behaviour and growth rates were unaffected by exposure to petroleum coke. There were no statistically significant differences between test groups and controls for any of the parameters measured. Sample 6-1-468 did not cause any cytogenetic effects in male rats exposed at levels up to and including 40 µg/l.
Reliability:	1, valid without restriction.

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5. Toxicity**5.7 Carcinogenicity**

Species: Mouse
Sex: Male/female
Strain: C3H
Route of administration: Dermal
Exposure period: Lifetime
Frequency of treatment: 3 times weekly
Post. Observation period: None
Doses: Coke samples at 25%, condensate sample at 100%
Result: Negative
Control Group: Yes
Method: Repeated dose dermal carcinogenicity study
Year: 1979
GLP: Yes
Test substance: Green petroleum coke CAS # 64741-79-3
 Calcined petroleum coke CAS # 64743-05-1

The following samples were tested:

Sample No. 3-1-134

Green coke (Ground, solid condensed emission/delayed process coke), tested as a 25% suspension in mineral oil.

Sample No. 4-1-140

Green coke (Delayed process, micronized), tested as a 25% suspension in mineral oil.

Sample No. 6-1-468

Green coke (Fluid process, micronized), tested as a 25% suspension in mineral oil.

Sample No. 7-1-100

Process water from delayed process coke, tested undiluted.

Positive control substance

Benzo-a-pyrene, tested as 0.05% and 0.15% solutions in mineral oil

Vehicle control

Veterinary grade mineral oil

Method:

The 4 test materials and the vehicle control were applied (100 µl) three times weekly to the shaven dorsal surface of groups of 25 male and 25 female mice for their lifetimes. Treatment was stopped and the animals sacrificed when the study director considered it to be appropriate for humane reasons.

The benzo-a-pyrene positive control groups were treated twice weekly for their lifetimes. Additionally 25 male and 25 female control mice were included. These animals were shaved only, without further treatment.

The animals, aged 66 days at the commencement of the study, were checked daily for viability and three times weekly for a more comprehensive clinical examination. Body weights were recorded every two weeks.

Pathology was carried out on all mice that died and histology was

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conducted on a wide range of tissues and organs.

Result:

The positive control groups had decreased survival times compared with the vehicle and "shaved only" negative controls. Survival was unaffected by treatment with any of the coke

samples or the condensate.

Although some body weight effects were recorded, there were no consistent treatment-related trends for the coke and condensate samples.

No neoplastic changes were recorded at the treatment site for the negative controls or any of the coke and condensate test groups. In contrast, squamous cell neoplasms developed at the treatment sites in the positive control animals.

The incidence of acanthosis and hyperkeratosis observed together with the number of spontaneous mammary tumours recorded in the animals is shown in the table below:

Sample	Acanthosis (%)		Hyperkeratosis (%)		No. of mice with mammary tumours
	M	F	M	F	
Shaved	21	16	16	12	6
Vehicle	42	46			4
3-1-134	68	83	12	9	4
4-1-140	79	92	38	42	9
6-1-468	96	72	71	36	8
7-1-100	12	17	48	54	5

In conclusion, the study demonstrated that neither the coke samples nor the condensate were carcinogenic in a lifetime skin painting study in mice.

Apart from an increased incidence of acanthosis and hyperkeratosis of the skin at the treatment site, there were no other treatment related effects.

Reliability:

1, valid without restriction. This is a well described and documented study. All the data are presented such that independent evaluation could be undertaken if required.

(9)

5.11 Experience with Human Exposure**Remark:**

Although the effects of green or clacined coke on man have not been studied, there have been several epidemiology studies conducted at manufacturing plants where petroleum coke was in use. The common feature of these studies was the examination of the effects of dusts and PAHs on the workforce, but in none of them was it possible to identify the contribution of coke to the effects observed.

One study was conducted to evaluate respiratory function and reported respiratory disease among workers exposed to petroleum coke dust. In this study, 90 employees (55% of the workforce) participated in a medical investigation which included a respiratory questionnaire, pulmonary function tests (PFT) and chest

5. Toxicity

X-ray. The medical evaluation revealed abnormal PFT results among 9 (10%) current employees. The PFT abnormalities were significantly related to dust exposure as

measured by length of employment, age and a history of working for 5 years or longer in the mobile equipment department. Chest X-rays showed no evidence of pneumoconiosis. Although no pneumoconiosis was detected, the medical study did find evidence of occupationally-related pulmonary function abnormalities.

(8)

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