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Contents

SUMMARY

The Petroleum Coke category consists of two substances; green coke and calcined coke. These two substances are grouped together in a category based on their similarity of manufacturing processes which results in similar physical chemical characteristics and chemical composition. The principal difference is the amount of residual hydrocarbon (also termed volatile matter) in the two products. Petroleum coke (both green and calcined) is a black-colored solid produced by the high pressure thermal decomposition of heavy (high boiling) petroleum process streams and residues. Green coke is the initial product from the cracking and carbonization of the feedstocks to produce a substance with a high carbon-to-hydrogen ratio. Green coke undergoes additional thermal processing to produce calcined coke. The additional processing removes volatile matter and increases the percentage of elemental carbon, which results in a lower potential for toxicity for calcined coke.

The hazard potential for the petroleum coke category has been characterized by evaluating existing data, testing green coke to fill data gaps, then 'reading across' the green coke results to the other category member, calcined coke. This is justified because, as stated above, green coke contains higher levels of volatile matter, and therefore, it is "worse case" by comparison to calcined coke. Physical-chemical properties, environmental fate, environmental effects and health effects are summarized below, and more fully discussed in the body of the category analysis. The primary routes for human exposure are dermal and inhalation. With the exception of *in vitro* studies, the mammalian health data provided in this report are from inhalation and dermal studies.

Physical-Chemical Properties:

Because petroleum coke (both green coke and calcined coke) is the substance remaining from treating heavy petroleum feedstocks with high temperature and pressure, many of the physical-chemical properties are not meaningful at ambient environmental conditions. At ambient temperature and pressure, petroleum coke exists as a solid, and because it consists predominantly of elemental carbon and a hardened residuum remaining from the feedstocks, the High Production Volume (HPV) Chemical Challenge Program physical-chemical endpoints either cannot be measured using recommended testing procedures or would not provide meaningful information.

Environmental Fate:

If released to the environment, both forms of petroleum coke would not be expected to undergo many of the HPV environmental fate pathways. Because petroleum coke is predominantly elemental carbon and a hardened residuum, it would not be subject to photolytic processes. These substances do not contain hydrolysable chemical bonds, nor are they susceptible to biodegradation by microorganisms. Depending on the particle size and density of the material, terrestrial releases will become incorporated into the soil or transported via wind or surface water flow. If released to the aquatic environment, petroleum coke will either incorporate into sediment or float on the surface, depending on the particle size and density in relation to water.

Ecotoxicity:

Aquatic and terrestrial ecotoxicity tests were performed to assess the hazard of green petroleum coke to representative aquatic organisms and terrestrial soil-dwelling invertebrates and vascular plants. Testing of selected terrestrial species was included because petroleum coke is sometimes used in a manner that can result in exposure to terrestrial organisms. Aquatic exposures were prepared as water accommodated fractions (WAFs) and attempts were made to analytically quantify specific organic and inorganic constituents of petroleum coke in the WAF solutions. None of those constituents of petroleum coke were present in the WAF solutions at

responses of the respiratory tract to high concentrations of insoluble particles rather than compound specific-induced effects, and are supported by the lack of systemic toxicity observed in the two-year animal studies. Using results of two-year chronic toxicity/carcinogenicity studies in rats and monkeys, a conservative estimate of the portal-of-entry repeated-dose LOAEL was < 10 mg/m^3, and the inhalation repeated-dose systemic NOAEL was estimated to be >30 mg/m^3. Additionally, green coke was not carcinogenic in rats or monkeys at 30 mg/m^3 (the highest concentration tested). Petroleum coke repeated-dose hazard potential is low.

In Vitro Genetic Toxicity – Gene mutation: Green coke was not mutagenic in standard *in vitro*

1. DESCRIPTION OF PETROLEUM COKE

Petroleum coke is produced through the thermal decomposition of heavy petroleum process streams and residues. The three most common feedstocks used in coking operations are 1) reduced crude (vacuum residue), 2) thermal tar, and 3) decant oil (catalytically cracked clarified oil) (Onder and Bagdoyan, 1993). These feedstocks are heated to thermal cracking temperatures and pressures (485 to 505°C at 400 kPa) that create petroleum liquid and gas product streams. The material remaining from this process is a solid concentrated carbon material, petroleum coke (Ellis and Paul, 2000b; EC, 2003).

Petroleum cokes can be categorized as either green or calcined coke. The initial product of the coking process, green coke, is used as fuel, in gasification and metallurgical processes, or as feedstock to produce calcined coke. Calcined coke is produced when

part of the ash and particulates (Ellis and Paul, 2000b). Metal concentrations in coke normally increase upon calcining due to the weight loss from evolution of the volatile matter (Lee

process of calcining removes moisture, redu

Comparison of Properties of Green Coke from Supplier Candidates and Selected Green Coke Supplier for HPV Test Material				
Property	**Five Candidate Refinery Coke Quality Ranges**		**Coke Quality for Refinery that Provided HPV Testing Sample**	
	Value	**Percentile**	**Value**	**Percentile**
Sulfur (Wt. %)	4.20 – 6.00	43 - 93	5.75	86
Nickel (ppm)	250 - 500	50 - 90	300	58
Vanadium (ppm)	1,000 – 1,500	65 - 84	1,200	75
Volatile Matter (Wt. %)	10.0 – 15.0	25 - 100	12.0	75

[1] Pace Consultants Inc., 2001

Detailed analysis of the selected green coke test sample is provided in Appendix B.

4. PHYSICAL-CHEMICAL PROPERTIES

Petroleum coke is a product of extreme temperature and pressure treatments that convert heavy petroleum feedstocks into a solid substance composed predominately of carbon. Because of its structural and compositional characteristics, developing the physical-chemical and environmental fate endpoints of the HPV program would not be feasible using standard OECD testing methods.

4.1. Physical-Chemical Screening Information Data Set (SIDS)

The physical-chemical endpoints in the HPV chemicals program include the following:

Melting Point
Boiling Point
Vapor Pressure
Octanol/Water Partition Coefficient

Conclusions: The HPV physical-chemical endpoints for green or calcined petroleum coke either cannot be measured or would not provide meaningful data at ambient environmental conditions.

4.2. Assessment Summary for Physical-Chemical Endpoints

Green petroleum coke is a complex mixture of mostly elemental carbon with inorganic and organic constituents embedded in a solid poly-crystalline porous matrix. Under ambient environmental conditions, characteristics of melting point, boiling point, vapor pressure, partition coefficient, and water solubility cannot be measured in either green or calcined petroleum coke due to analytical limitations or the physical nature of petroleum coke.

to hydrolyze include alkyl halides, amides, carbamates, carboxylic acid esters and lactones, epoxides, phosphate esters, and sulfonic acid esters (Harris, 1982b).

Petroleum coke is composed of elemental carbon and other components that are not susceptible to nucleophilic substitution. Therefore, petroleum coke is not subject to hydrolysis, and this fate process will not be an important degradative pathway in the environment.

Conclusion: Hydrolysis is not an important degradative pathway for green or calcined

majority of the constituents in petroleum coke do not contain the chemical bonds needed for microbial metabolism.

6. ENVIRONMENTAL EFFECTS

6.1. AQUATIC TOXICITY

6.1.1. Aquatic Endpoints

The potential hazard of green petroleum coke to freshwater aquatic organisms was assessed by testing a fish (*Pimephales promelas*), an invertebrate (*Daphnia magna*), and an alga (*Selenastrum capricornutum*). All studies employed aqueous exposure solutions prepared as water accommodated fractions (WAFs) in accordance with OECD recommendations for testing complex mixtures having low water solubility (OECD, 2000a). Green coke used to prepare the WAF solutions was milled and sieved to approximately 2 mm grain size and was separated from the aqueous phase following a period of mixing. Under an aquatic spill scenario, adverse effects of petroleum coke on aquatic organisms potentially could arise due to physical effects of coke particulate matter on respiratory membranes of the organisms. The 2 mm grain size allowed the segregation of the solid particles following the preparation of the WAF solutions.

Prior to testing, the test sample of green petroleum coke was characterized for a series of specific inorganic constituents and predominantly un-alkylated polycyclic aromatic hydrocarbons (PAH). A subset of those analytes and compounds were used as markers in the WAF solutions during each aquatic toxicity test. Attempts to measure these constituents in fresh and aged WAF solutions used in the three aquatic toxicity tests showed their concentrations to be less than the minimum quantifiable limits for the methods used (detection limits were 5 g/L for PAHs, 0.4 g/L to 200 g/L for metals, and 5.1 mg/L for sulfur). The aquatic toxicity test endpoints are presented as nominal WAF loading rates. Acute effects on aquatic organisms are unlikely except at concentrations above the solubility limits of the measured constituents. However, the solubility limits could not be 2 12(WAF)6aogiED Tcustst ens in b(c)-3(c)-useTJ-0.0003 Tc -0.0021 Tw 19.479 0 Td[((Wthe me

Conclusion: The results of this study indicate that WAFs of green petroleum coke are not acutely toxic to freshwater fish at the loading rate used in the test.

6.1.3. Acute Toxicity to Freshwater Invertebrates

The test with the freshwater invertebrate, *Daphnia magna*, was conducted following

96-hour E_rL_{50} >1000 mg/L (WAF nominal loading rate)

96-hour NOELR <1000 mg/L (WAF nominal loading rate)

Conclusion: The results indicate that WAFs of green petroleum coke may produce a slight growth inhibition in freshwater algae at the loading rate used in the test.

6.2. TERRESTRIAL TOXICITY

6.2.1. Terrestrial Endpoints

Petroleum coke is sometimes used in a manner that can result in exposure to selected terrestrial species. For example, it is used in soil as a grounding agent to protect sensitive installations from lightning strikes (NLSI, 2002), and it has been experimentally used as an absorbent for the removal of crude oil from soils (Narayannan and Arnold, 1997). Therefore the potential hazards to terrestrial organisms were evaluated.

The hazards of green petroleum coke to terrestrial organisms were assessed by testing an earthworm (*Eisenia fetida*), and three species of terrestrial plants (corn, *Zea mays*; radish, *Raphanaus sativus*; and soybean, *Glycine max*). Testing methods followed OECD and/or EPA guidelines. All studies were conducted as limit tests using single maximum test concentrations of 1000 mg/kg (dry weight) of green petroleum coke incorporated into the soil. Petroleum coke used in terrestrial testing was milled to mean particle size of 3.3 µm. The small particle size permitted the incorporation of the substance in soil and maximized the potential for contact between the coke particles and the test species.

Prior to testing, the test sample of green petroleum coke was characterized for selected inorganic constituents and predominantly un-alkylated polycyclic aromatic hydrocarbons (PAH). It was anticipated that those analytes and compounds could be used as dose verification markers when analyzed in the soil during each test. Subsequent analytical method verification trials showed that the PAH markers were below analytical detection limits, [illegible] while

21-day NOEC = 1000 mg/kg (nominal concentration)

Radish: No statistically significant differences ($p > 0.05$) were found for seedling emergence, seedling survival, seedling height, or shoot dry weight between the dosed and control groups. Condition scores revealed no treatment-related effects. The results for the test with radish were:

21-day LC_{50} >1000 mg/kg (nominal concentration)

21-day NOEC = 1000 mg/kg (nominal concentration)

Soybean: No statistically significant differences ($p > 0.05$) were found for seedling emergence, seedling survival, seedling height, or shoot dry weight between the dosed and control groups. Condition scores revealed no treatment-related effects. The results for the test with soybean were:

21-day LC_{50} >1000 mg/kg (nominal concentration)

21-day NOEC = 1000 mg/kg (nominal concentration)

Conclusion: The results indicate that green petroleum coke is not toxic to terrestrial plants at the concentration tested.

6.2.3. Toxicity to Soil Dwelling Organisms

Toxicity of green petroleum coke to earthworms (*E. fetida*) was evaluated following OECD guidelines (OECD, 1984c) in a 14-day limit test using soil-incorporated petroleum coke at a concentration of 1000 mg/kg (dry weight). Un-treated soil was used in the negative control group. The test and control experimental groups consisted of four replicate containers each holding 750 g of soil and 10 earthworms. During the 14-day test, the earthworms were assessed for survival, burrowing behavior, general appearance, and mean body weight (Wildlife International Ltd., 2006e).

No mortality occurred in any replicate of the control or the 1000 mg/kg treatment groups, and in general, earthworms were normal in appearance. None of the earthworms of the control or treatment groups showed any aversion to the soil or in soil burrowing behavior. There were no statistical differences ($p > 0.05$) in earthworm body weight or change in body weight when measured at the end of the test. The results of the test were defined as follows:

14-day LC_{50} >1000 mg/kg (nominal concentration)

14-day no mortality concentration = 1000 mg/kg (nominal concentration)

14-day NOEC = 1000 mg/kg (nominal concentration)

Conclusion: The results indicate that green petroleum coke is not toxic to earthworms at the concentration tested.

6.3. Assessment Summary for Environmental Effects

Petroleum coke (green coke) had no effects on aquatic vertebrates and invertebrates and only a slight effect on algae at a WAF loading rate of 1000 mg/L. Petroleum coke did not produce any adverse effects in earthworms and three species of terrestrial vascular plants at 1000 mg/kg soil. Green coke is considered to have a higher potential to induce

environmental effects than calcined coke due to green coke’s higher concentration of

with no treatment-related deaths. Based on the OECD 421 study, the acute inhalation toxicity of both green and calcined coke is estimated to be > 300 mg/m^3.

7.1.2. Repeated-Dose Toxicity

Two-year whole-body inhalation toxicity studies of sponge-form delayed process green coke were conducted in both Sprague-Dawley rats and Cynomolgus monkeys (IRDC, 1985; Klonne *et al*., 1987). Both studies were conducted at concentrations of 10 and 30 mg/m^3 of green coke, which had been micronized into fine particles to aid in aerosol generation. The average mass median aerodynamic particle size of 3.1 ± 1.9 m was stable over the entire exposure period. The animals were exposed 6 h/day, 5 days/week, except holidays, for two years. Group sizes in the studies were four mature adult monkeys per sex per control and exposed groups, and 150 rats per sex per control and exposed groups. In life parameters evaluated for monkeys and rats included weekly clinical observation, blood and clinical chemistry analyses prior to exposure and at 1, 3, 6, 12, 18, and 24 months, and comprehensive eye examinations at the same intervals that blood chemistries were conducted. Ten rats/sex/group were pre-selected for cytogenetic evaluation (results presented below under Section 7.1.3.2 for *in vivo* genotoxicity) at five days, 12 months and 24 months of exposure; however due to high mortality in control and exposed groups, only five to eight rats per group were evaluated at 22 months, rather than 24 months. For rats, interim sacrifices were conducted at 5 days, 1, 3, 6, 12 and 18 months with terminal sacrifice at 24 months. Fasting body weights and the weights of heart, lung plus trachea, liver, gonads, adrenals, thyroid/parathyroids, kidneys, spleen and brain were recorded at each scheduled necropsy. Thirty-one designated tissues from ten rats/sex in the control and high exposure groups were examined microscopically after 3,6,12 and 18 months; all remaining animals from control and high exposure level groups were evaluated after 24 months of exposure. All animals sacrificed *in extremis* or found dead were also evaluated. Only lung plus trachea (at 12, 18 and 24 months) and nasal turbinates (at 24 months) were examined microscopically from rats in the 10 mg/m^3 exposure group. All monkeys were sacrificed after 24 months of exposure. The same 31 tissues were evaluated microscopically in control and high dose groups; weights for the same organs listed for rats were also obtained. Again, only lung plus trachea and nasal turbinates were microscopically evaluated for monkeys in the 10 mg/m^3 exposure group. There were no treatment-related effects on body weights or mortality in rats or monkeys.

The only treatment-related effects reported from these chronic studies were for the lungs in both rats and monkeys. There were dose-related increases in lung plus trachea weights and inflammatory changes in the lungs in rat and monkey petroleum coke exposed groups, accompanied by pigment accumulation (presumed to be test material) in the lung and associated lymph nodes. The lung histological changes in treated rats included pulmonary interstitial inflammatory responses with focal fibrosis, bronchiolization, sclerosis, squamous alveolar metaplasia and the presence of keratin cysts. The keratin cysts were considered to be an advanced stage of squamous alveolar metaplasia but were not considered to be an oncogenic response. The severity of the rat histological changes was related to the duration and concentration of exposure, and was considered to be non-reversible. These lung effects in the rat are considered a non-specific response of the lung to high concentrations of insoluble particles rather than compound specific induced effects, also referred to as rat lung particle overload, and are unlikely to be relevant to humans (Snipes, 1995; Mauderly and McCunney, 1996). By contrast, the primates exhibited lung and pulmonary lymph node pigment accumulation (presumed to be test material) at both exposure levels as a result of phagocytosis by pulmonary macrophages; however, inflammatory or metaplastic changes, as observed in

coke in *Salmonella typhimurium* strains TA 98 and TA 100. Petroleum coke was ground in a mortar, then 50 grams were sequentially extracted with four solvents of increasing polarity (benzene, chloroform, methanol and acetone). Samples were taken at each extraction step, dried, weighed and dissolved in DMSO. The non-extractable residual material (99.71% of starting material) was also tested as a DMSO suspension. The five samples (four extraction steps & the non-extractable residue) were tested for mutagenic potential in TA 98 and TA 100 at 0.1 – 4 mg/plate with and without metabolic activation (liver S-9 from Aroclor 1254 induced male Sprague-Dawley rats). The criteria for a positive response were defined as the observations of a dose-related response and a three-fold or higher increase in revertants per plate as compared to controls. By these criteria, no mutagenic activity was observed in any of the coke solvent fractions or non-extractable residue.

Green coke (sponge-form delayed process; same sample as used in the rat and monkey two-year studies described in Section 7.1.2) was evaluated in a modified bacterial mutagenicity assay (Dalbey *et al*., 1998; ASTM International, 2004b). It has been shown previously that the standard bacterial assay is insensitive to certain classes of materials, including petroleum substances (Blackburn *et al.*, 1984; 1986). In the modified assay, samples are typically dissolved in cyclohexane and subsequently extracted with dimethyl sulfoxide (DMSO) to produce aqueous compatible solutions which readily interact with

Delayed process green coke was evaluated for its ability to produce chromosome aberrations in a bone marrow cytogenetic assay (Hazleton, 1981a). Male Sprague-Dawley rats were exposed via inhalation to concentrations of 0, 10 and 40 mg/m^3 petroleum coke with a particle size of less than 5 m. Rats in the 10 mg/m^3 exposure group were exposed 6 h/day, 5 days/week for a total of 20 exposures. Rats in the 40 mg/m^3 were exposed 6 h/day for 5 days only. Control rats were held for the full 28 days of the study before assessment. The day after the last exposure, colchicine was administered to inhibit mitosis and bone marrow analyzed for chromosomal changes. There were no treatment-related chromosomal effects in the 10 mg/m^3 exposure group. In the 40 mg/m^3 exposure group, there were significant increases in the number of chromatid breaks, markers and total aberrations as compared to controls. The laboratory later determined that the slides had been inconsistently evaluated and misread in some cases. This study was therefore considered to be technically flawed and inconclusive.

To resolve uncertainty, a third *in vivo* cytogenetics study was conducted on bone marrow from male and female rats in the chronic inhalation study described in Section 7.1.2. (IRDC, 1985; Klonne *et al.*, 1987). Analysis was conducted on male and female Sprague-Dawley rats after exposure for five days, 12 months and 22 months to concentrations of 0, 10 and 30 mg/m^3 delayed process green coke dust. There were no significant differences from controls in chromosomal aberrations in any exposed animals

population accompanied the deposition of pigment. In the larynx, minimal squamous metaplasia of the respiratory epithelium was also observed. These effects were considered non-specific responses to high concentrations of insoluble particles rather than compound-specific induced effects (Snipes, 1995). A parental portal-of-entry NOAEL could not be determined since effects were observed at the lowest exposure. The parental portal-of-entry LOAEL was < 30 mg/m^3, the lowest concentration tested.

No parental systemic or reproductive toxicity was observed in either sex. There were no treatment-related effects on the offspring. The parental systemic, reproductive, and developmental NOAELs were > 300 mg/m^3.

Conclusion: Based on the OECD 421 Reproductive/Developmental Toxicity Screening Test, petroleum coke demonstrated low reproductive and developmental toxicity. Parental systemic toxicity, reproductive toxicity, and developmental toxicity NOAELs were >300 mg/m^3, which was the highest concentration tested.

8. MATRIX OF PETROLEUM COKE CATEGORY DATA

Table 3

PETROLEUM COKE CATEGORY DATA MATRIX

Endpoint	Petroleum Coke (Green) CAS # 64741-79-3	Petroleum Coke (Calcined) CAS # 64743-05-1
Physical-Chemical Properties		
Melting Point	N/A[a]	N/A
Boiling Point	N/A	N/A
Vapor Pressure	N/A	N/A
Partition Coefficient	N/A	N/A
Water Solubility	N/A	N/A
Environmental Fate		
Photodegradation	N/A	N/A
Stability in Water	N/A	N/A

9. CATEGORY ANALYSIS CONCLUSIONS

It is appropriate for green coke and calcined coke to be grouped together in one category. This grouping is justified based on their manufacturing processes, which result in similar physical chemical characteristics and chemical composition. The hazard potential for the petroleum coke category was characterized by summarizing existing data, and testing delayed process green coke to fill in the data gaps identified in existing data. Green coke is considered to have a higher potential to induce environmental and/or human effects than calcined coke due to its higher volatile matter. Therefore, the green coke hazard study results have been conservatively extrapolated to calcined coke in lieu of testing calcined coke.

Petroleum coke is a complex mixture of mostly elemental carbon with inorganic and organic constituents embedded in the carbon matrix. In general, these constituents do not contain the chemical bonds that engage in photolytic or hydrolytic reactions. If released to the environment, petroleum coke would be expected to be non-reactive and either disperse or remain in the environmental compartment to which it was released. Therefore, depending on factors such as particle size and density relationships between the petroleum coke and environmental media, releases to terrestrial or aquatic environments would result in incorporation of the material in soils/sediments or dispersal via wind/water action. Biodegradation would not be an important fate process because the majority of the constituents in petroleum coke do not contain the chemical bonds needed for microbial metabolism.

Petroleum coke has an extremely low environmental hazard potential. Petroleum green coke demonstrated no effect on aquatic vertebrates and invertebrates, and only a slight effect on algae at 1000 mg/L (WAF). Petroleum green coke did not produce any adverse effects when tested against terrestrial soil-dwelling invertebrates and vascular plants at 1000 mg/kg soil.

Petroleum coke has a low health hazard potential. Green coke is not acutely toxic. The acute inhalation toxicity NOAEL was estimated to be > 300 mg/m^3. Findings observed in repeated-dose and chronic inhalational toxicity studies were confined to portal-of-entry effects that are attributed to non-specific effects of insoluble particles rather than petroleum coke-specific effects. The repeated-dose portal-of-entry LOAEL and systemic NOAEL were estimated to be < 10 mg/m^3 and > 30 mg/m^3, respectively. Green coke was not mutagenic *in vitro* in standard bacterial or mammalian cell assays. Green coke was mutagenic in modified *in vitro* bacterial assays developed to optimize detection of mutagenicity for certain classes of compounds that are negative in the standard bacterial assay. Green coke was not genotoxic in *in vivo* bone marrow chromosome cytogenetic assays. Green coke did not induce reproductive or developmental toxicity at exposures up to 300 mg/m^3. The parental systemic, reproductive, and developmental toxicity NOAELs were all > 300 mg/m

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11.

12. GLOSSARY

NOTE:

Test methodology is described in OECD Guideline 203, in OECD Guidelines for the Testing of Chemicals.

***Daphnia* sp., Acute Immobilization Test:** In a one or two-day exposure, acute toxicity is defined by the EC_{50}, the concentration of test substance in water which causes immobilization to 50% of the test population of invertebrates. Test methodology is described in OECD Guideline 202, Part 1, in OECD Guidelines for the Testing of Chemicals.

Alga, Growth Inhibition Test: In a three-day exposure, growth inhibition is defined by the EC_{50}, the concentration of test substance in growth medium which results in a 50% reduction in either alga cell growth or growth rate relative to a control group. Test methodology is described in OECD Guideline 201, in OECD Guidelines for the Testing of Chemicals.

Elemental Carbon: Elemental refers to the adjective form of the word, *element*. Thus for example, in chemistry, it refers to matter composed of only one chemical element. Graphite and diamond are types of elemental carbon. **(Wikipedia 2007a http://en.wikipedia.org/wiki/Main_Page)**

Endpoint: In the context of the EPA High Production Volume Challenge Program, an endpoint is a physical-chemical, environmental fate, ecotoxicity, and human health attribute measurable by following an approved test methodology (e.g., OECD Guidelines for Testing of Chemicals). Melting point, biodegradation, fish acute toxicity, and genetic toxicity are examples of endpoints that are measured by an approved test method. **(US EPA 1999)**

Environmental Fate Effects – all endpoints (OECD definitions)

Photodegradation: The photochemical transformation of a molecule into lower molecular weight fragments, usually in an oxidation process. This process may be measured by Draft OECD Guideline, "*Phototransformation of Chemicals in Water – Direct and Indirect Photolysis*". This process also may be estimated using a variety of computer models.

Stability in Water: This environmental fate endpoint is achieved by measuring the hydrolysis of the test substance. Hydrolysis is defined as a reaction of a chemical RX with water, with the net exchange of the group X with OH at the reaction center. Test methodology for hydrolysis is described in OECD Guideline 111, in OECD Guidelines for the Testing of Chemicals.

Transport Between Environmental Compartments: This endpoint describes the distribution of a chemical between environmental compartments using fugacity-based computer models. The results of the model algorithms provide an estimate of the amount of the chemical within a specific compartment. The environmental compartments included in many models are air, water, soil, sediment, suspended sediment, and aquatic biota.

Biodegradation: Breakdown of a substance catalyzed by enzymes *in vitro* or *in vivo*. As an endpoint in EPA's HPV program, biodegradation is measured by one of six methodologies described in OECD Guidelines 301A-F, in OECD Guidelines for the Testing of Chemicals.

Exposure: Contact made between a chemical, physical, or biological agent and the outer boundary of an organism. Exposure is quantified as the amount of an agent available at the exchange boundaries of the organism (e.g., skin, lungs, gut). **(US EPA 2002).**

Feedstock: A refinery product that is used as the raw material for another process; the term is also generally applied to raw materials used in other industrial processes. **(Speight, 2007).**

Female Mating Index: Number of females with confirmed mating (sperm and/or vaginal plug)/number of females placed with males. **(HLS 2006)**.

Green coke (raw coke): This is the primary solid carbonization product from high boiling hydrocarbon fractions obtained at temperatures below 900° K. It contains a fraction of matter that can be released as volatiles during subsequent heat treatment at temperatures up to approximately 1600° K. This mass fraction, the so-called volatile matter, is in the case of green coke between 4 and 15%, but it depends also on the heating rate. **(IUPACe rr --[Greeletile mero)1(o)5(Tgres b)5(/To**

reproductive organs, the related endocrine system, or pregnancy outcomes. The manifestation of such toxicity may include, but not be limited to, adverse effects on onset of puberty, gamete production and transport, reproductive cycle normality, sexual behavior, fertility, gestation, parturition, lactation, developmental toxicity, premature reproductive senescence, or modifications in other functions that are dependent on the integrity of the reproductive systems. **(US EPA 1996f)**

Heavy Petroleum Process Streams: Petroleum streams boiling higher than approximately 650^{o}F (345^{o}C), including distillation residues and the absence of low-boiling components. **(Altgelt and Boduszynski 1994).**

Lowest-Observed-Adverse-Effect Level (LOAEL): The lowest exposure level at which there are statistically or biologically significant increases in frequency or severity of adverse effects between the exposed population and its appropriate control group **(US EPA 2002).**

No-Observed-Adverse-Effect Level (NOAEL): The highest exposure level at which there are no biologically significant increases in frequency or severity of adverse effects between the exposed population and its appropriate control group; some effects may be produced at this level, but they are not considered adverse or precursors to adverse effects **(US EPA 2002)**.

Petroleum (crude oil): A naturally occurring mixture of gaseous, liquid, and solid hydrocarbon compounds usually found trapped deep underground beneath impermeable cap rock and above a lower dome of sedimentary rock such as shale; most petroleum reservoirs occur in sedimentary rocks of marine, deltaic, or estuarine origin **(Speight 2007)**.

Petroleum Coke: A solid, carbonaceous residue produced by thermal decomposition of heavy petroleum fractions or cracked stocks, or both **(ASTM 2005)**.

Polycyclic aromatic compound (PAC): PAC includes multi-ringed aromatic hydrocarbons in which one or more atoms of nitrogen, oxygen or sulfur (a heteroatom) replace one of the carbon atoms in a ring system. The PACs can be grouped according to the heteroatom they contain. ***(API 2007)***

Polycyclic Aromatic Hydrocarbon (PAH)

Target Organ: The biological organ(s) most adversely affected by exposure to a chemical or physical agent **(US EPA 2002).**

Thermal Cracking: A refining process in which heat and pressure are used to break down, rearrange, or combine hydrocarbon molecules. Thermal cracking includes gas oil visbreaking, fluid coking, delayed coking, and other thermal cracking processes (e.g., flexicoking). **(US DOE 2007)**

Thermal Decomposition: Thermal decomposition is a chemical reaction where a chemical substance breaks up into at least two chemical substances when heated. ***[Wikipedia 2007b http://en.wikipedia.org/wiki/Main_Page]***

Volatile Matter: The mass loss on heating expressed as a percent loss of the moisture free sample used. Samples having a thermal history above 600º C are excluded. Volatile matter is determined by measuring the mass loss of the coke when heated under the exact conditions of the ASTM standard method D 6374 – 99). To ensure the sample is moisture free it is dried to a constant weight at 95 to 105º C prior to the procedure. The procedure involves heating the sample to 950 ± 20 º C for five minute periods to constant mass (± 0.5 mg) (**ASTM 2004a**).

APPENDIX A - Category Members

CAS No.	EINECS No.
64741-79-3	265-080-3

Coke (petroleum)
A solid material resulting from high temperature treatment of petroleum fractions. It consists of carbonaceous material and contains some hydrocarbons having a high carbon-to-hydrogen ratio (API, 1985).

64743-05-1	265-210-9

Coke (petroleum), calcined
A complex combination of carbonaceous material including extremely high molecular weight hydrocarbons obtained as a solid material from the calcining of petroleum coke at temperatures in excess of 1,000^{o}C (1800^{o}F). The hydrocarbons present in calcined coke have a very high carbon-to-hydrogen ratio (API, 1985).

APPENDIX B – Composition of Green Coke Samples Used in Toxicology Studies

	Delayed Process Green Coke - 2003 Sample [1]	API Sample

			Green Coke - 2003 ple [1]		API Sample # 4-1-140 [2]	Micronized Delayed Process Green Coke – 1981 sample [3]	
			micro-nized (initial)	micro-nized (final)	Delayed Process Coke	1981 Analysis	1984 Analysis
			<29.6				
			121.6	158.7			
			<14.8				
			<14.8	1.7			
			<14.8	4.6			
			<17.8	2.3			
			247	276.1			
					<1	<1	<0.01
			<44.4	20.5			
			<14.8	<1.16			
			60.9	65.5			
			<29.6	7.3			
			<29.6	16.0			
Na (sodium)	133	87.8	114.6	99.0			
Ni (nickel)	367.1	319.6	351.7	304.6	95	78	85
P (phosphorus)	<19.3	19.8	30.3	25.0		—	
Pb (lead)	<19.3						