IX. APPENDIX I

METHOD FOR SAMPLING AND ANALYSIS OF HYDROQUINONE IN AIR

This recommended sampling and analytical method has been described in Method No. S57 by the Measurements Research Branch of NIOSH [100].

Principle of the Method

(a) A known volume of air is drawn through a mixed cellulose ester membrane filter to trap the hydroquinone aerosol present. This method is not applicable for sampling environments where significant hydroquinone vapor may be present.

(b) Immediately after sample collection, the filter in the cassette is transferred into a jar and treated with aqueous acetic acid. Samples are stored and shipped in jars containing acetic acid solution.

(c) An aliquot of the sample is injected into a high-pressure liquid chromatograph (HPLC) equipped with a variable wavelength UV detector set at 290 nm.

(d) The area of the resulting sample peak is used as a measure of analyte concentration by comparison with corresponding areas obtained from the injection of standards.

Range and Sensitivity

(a) This method was validated over the range of 0.84-4.05 mg/cu m at an atmospheric temperature and pressure of 20 C and 762 mmHg, using a 90 liter sample. For a sample size of 90 liters the working range of the method is estimated to be 0.4-8.0 mg/cu m.

(b) The method may be extended to higher values by further dilution of the sample solution. The sensitivity of the analytical method is estimated to be at least 1.5 μg per ml.

Interference

(a) When two or more compounds are known or suspected to be present in the air, such information, including their suspected identities, should be transmitted with the sample.

(b) It must be emphasized that any other compound which has the same retention time as the analyte at the operating conditions described in this method is an interference. Retention time data based on a single set of conditions cannot be considered as proof of chemical identity.

Precision and Accuracy

(a) The Coefficient of Variation (CVT) for the total analytical and sampling method in the range of 0.84-4.05 mg/cu m was 0.061.

(b) A collection efficiency of at least 96% was determined for the collection medium; thus, no significant bias was introduced in the sample collection step. There was also no bias in the analytical method--the average recovery from the filters was 99.4%. In addition, the samples were found to be stable when stored in the dilute acetic acid solution for 7

days. Thus, CVT is a satisfactory measure of both accuracy and precision of the sampling and analytical method.

Advantages and Disadvantages of the Method

(a) The sampling device is small, portable, and involves no liquids. Interferences are minimal, and most of those which do occur can be eliminated by altering chromatographic conditions. The filters are analyzed by means of a quick, instrumental method.

(b) One disadvantage is that some sample workup is required in the field to insure the stability of the sample. This step involves the transfer of the sample filter into a jar and addition of an aqueous solution of acetic acid.

Apparatus

(a) Sampling equipment. The sampling unit for the collection of personal air samples for the determination of organic aerosol has the following components:

(1) Filter. The filter unit consists of the filter medium described in (b) below and a 37-mm three-piece cassette filter holder.

(2) Personal sampling pump. A calibrated personal sampling pump whose flow can be determined to an accuracy of ±5% at the recommended flowrate is needed. The pump must be calibrated with a representative filter holder and filter in the line.

(3) Ointment jars. Use squat form with Teflon film gaskets and screw cap for sample storage.

(4) Graduated cylinder, 10 ml.

(5) 1% Aqueous acetic acid. Prepare a sufficient quantity for extraction and storage of samples.

(6) Thermometer.

(7) Barometer.

(8) Stopwatch.

(b) Mixed cellulose ester membrane filter, 0.8-micrometer pore size and 37-mm diameter. The filter is held in the three-piece cassette by a cellulose backup pad.

(c) High pressure liquid chromatograph equipped with a detector capable of UV detection at 290 nm.

(d) Column (25 cm x 4.6 mm I.D. stainless steel) packed with Partisil TM 10-ODS, or equivalent.

(e) Syringe, 100 µl, for HPLC injection.

(f) An electronic integrator or some other suitable method for measuring peak areas.

(g) Microliter syringes, 10-microliter and other convenient sizes for making standard solution.

(h) Volumetric flasks, 25-milliliter and other convenient sizes for making standard solutions and sample dilutions.

Reagents

(a) Hydroquinone, reagent grade.

(b) Distilled water.

(c) Glacial acetic acid.

(d) Acetic acid in distilled water, 1%. Prepare by diluting 10 ml of glacial acetic acid to 1,000 ml with distilled water. This solution is used for sample extraction and all dilutions and also as the mobile phase for the HPLC analysis.

Procedure

(a) Cleaning of Equipment

All glassware used for the laboratory analysis should be detergent washed and thoroughly rinsed with tap water and distilled water.

(b) Calibration of Personal Pumps

Each personal pump must be calibrated with a representative filter cassette in the line (see Figure XI-2). This will minimize errors associated with uncertainties in the sample volume collected.

(c) Collection and Shipping of Samples

(1) Assemble the filter in the three-piece filter cassette holder and close firmly to insure that the center ring seals the edge of the filter. The cellulose membrane filter is held in place by a cellulose backup pad and the filter holder is held together by plastic tape or a shrinkable cellulose band. If the middle piece of the filter holder does not fit snugly into the bottom piece of the filter holder, sample leakage will occur around the filter. A piece of flexible tubing is used to connect the filter holder to the pump.

(2) Clip the cassette to the worker's lapel. Air being sampled should not be passed through any hose or tubing before entering the filter cassette.

(3) A sample size of 22.5 liters is recommended. Sample at a flowrate of 1.5 liters per minute. The flowrate should be known with an accuracy of at least ±5%.

(4) Turn the pump on and begin sample collection. Since it is possible for filters to become plugged by heavy particulate loading or by the presence of oil mists or other liquids in the air, the pump rotameter should be observed frequently, and the sampling should be terminated at any evidence of a problem.

(5) Terminate sampling after the predetermined time and note sample flowrate, collection time, and ambient temperature and pressure. If pressure reading is not available, record the elevation.

(6) Open the cassette filter holder. Carefully remove the cellulose membrane filter from the holder and cellulose backup pad with the aid of appropriate tweezers and transfer filter to the 2-ounce ointment jar.

(7) Add 10 ml of 1% acetic acid into the jar and properly cap unit. Gently swirl the jar to ensure that the filter is thoroughly wetted.

(8) Shipping. The ointment jars should be shipped in a suitable container, designed to prevent damage and leakage in transit.

(9) Blank. With each batch of samples, submit one filter which is subjected to exactly the same handling as for the samples except that no air is drawn through it. Label this as a blank. Submit one blank for every ten samples.

(10) Bulk sample. A bulk sample of the suspected material should be submitted to the laboratory in a glass containter lined with a

Teflon cap. Label of the bulk sample should match air samples for identification purposes.

(d) Analysis of Samples

(1) Preparation of samples:

(A) Transfer the sample solution to a 25-ml volumetric flask.

(B) Rinse at least twice with 5 ml of 1% acetic acid and add the washings to the volumetric flask.

(C) Make volume up to 25 ml with 1% acetic acid.

(2) Analysis by high pressure liquid chromatograph. The mobile phase is 1% acetic acid. The typical operating conditions for the liquid chromatograph are:

(A) 1.0 ml/min solvent flowrate

(B) Ambient column temperature

(C) 400-600 psi system pressure

(3) Injection. The first step in the analysis is the injection of the sample into the liquid chromatograph. A 100-μl sample aliquot is recommended for this analysis. The sample may be injected either by using an appropriate syringe or by filling a fixed volume sample loop provided that reproducibility requirements are satisfied. Duplicate injections of each sample and standard should be made. No more than a 3% difference in area is to be expected.

(4) Measurement of area. The area of the sample peak is measured by an electronic integrator or some other suitable form of area measurement, and results are read from a standard curve prepared as discussed in Calibration and Standards.

(e) Determination of Analytical Method Recovery

(1) Need for determination. To eliminate any bias in the analytical method, it is necessary to determine the recovery of the compound. The sample recovery should be determined in duplicate and should cover the concentration ranges of interest. If the recovery is less than 95%, the appropriate correction factor should be used to calculate the "true" value.

(2) Procedure for determining recovery. A known amount of the analyte, preferably equivalent to the sample concentration expected, is added to a representative cellulose membrane filter and air-dried. The analyte is then extracted from the filter with 10 ml of 1% acetic acid in a jar, and analyzed as described in (d) above. Duplicate determinations should agree within ±5%. A parallel blank filter is similarly prepared, extracted, and analyzed except that no sample is added to it.

(3) The sample recovery equals the average weight in μg recovered from the filter divided by the weight in μg added to the filter, or:

$$\text{Recovery} = \frac{\text{Average Weight } (\mu g) \text{ recovered - Blank } (\mu g)}{\text{Weight } (\mu g) \text{ added}}$$

The recovery value is used in paragraph (c) of Calculations if the recovery is less than 95%.

Calibration and Standards

(a) Hydroquinone stock solution, 90 μg/25 μl. Dissolve 0.0900 g of hydroquinone in 25 ml of 1% acetic acid. Prepare a fresh solution daily.

(b) From the stock standard solution, prepare at least six working standards to cover the concentration range of 90-360 μg/25 ml. Transfer 25- to 100-μl aliquots of the stock standard into 25-ml volumetric flasks and dilute to volume with 1% acetic acid.

(c) These series of standards are analyzed under the same HPLC conditions and during the same time period as the unknown samples. Curves are established by plotting concentrations in micrograms per 25.0 ml versus peak area.

NOTE: To minimize effect of variations in LC conditions and detector response due to sample cell conditions, frequent standardization should be practiced.

Calculations

(a) Read the concentration, in μg/25 ml, corresponding to the peak area from the standard curve. No volume corrections for sample aliquots analyzed are needed, because the standard curve is based on μg per 25.0 ml and the volume of sample injected is identical to the volume of the standards injected.

(b) Corrections for the blank must be made for each sample.

$$\mu g = \mu g \text{ sample} - \mu g \text{ blank}$$

where:

μg sample = μg found in sample filter

μg blank = μg found in blank filter

(c) Divide the total weight by the recovery to obtain the corrected μg/sample.

$$\text{Corrected } \mu g/\text{sample} = \frac{\text{Total Weight}}{\text{Recovery}}$$

(d) For personal sampling pumps with rotameters only, the following correction should be made.

$$\text{Corrected Volume} = f \times t \left(\sqrt{\frac{P_1}{P_2}} \times \frac{T_2}{T_1} \right)$$

where:

f = sample flowrate

t = sampling time

P1 = pressure during calibration of sample pump (mmHg)

P2 = pressure of air sampled (mmHg)

T1 = temperature (K) during calibration of sampling pump

T2 = temperature (K) of air sampled

(e) The concentration of the analyte in the air sampled can be expressed in mg per cu m (μg per liter = mg per cu m).

$$\text{mg/cu m} = \frac{\text{Corrected } \mu g}{\text{Volume of Air Sampled in Liters}}$$

where:

Corrected μg is determined as specified in paragraph (c) above

X. APPENDIX II

MATERIAL SAFETY DATA SHEET

The following items of information which are applicable to a specific product or material shall be provided in the appropriate block of the Material Safety Data Sheet (MSDS).

The product designation is inserted in the block in the upper left corner of the first page to facilitate filing and retrieval. Print in upper case letters as large as possible. It should be printed to read upright with the sheet turned sideways. The product designation is that name or code designation which appears on the label, or by which the product is sold or known by employees. The relative numerical hazard ratings and key statements are those determined by the rules in Chapter V, Part B, of the NIOSH publication, An Identification System for Occupationally Hazardous Materials. The company identification may be printed in the upper right corner if desired.

(a) Section I. Product Identification

The manufacturer's name, address, and regular and emergency telephone numbers (including area code) are inserted in the appropriate blocks of Section I. The company listed should be a source of detailed backup information on the hazards of the material(s) covered by the MSDS. The listing of suppliers or wholesale distributors is discouraged. The trade name should be the product designation or common name associated with the material. The synonyms are those commonly used for the product, especially formal chemical nomenclature. Every known chemical designation or

competitor's trade name need not be listed.

(b) Section II. Hazardous Ingredients

The "materials" listed in Section II shall be those substances which are part of the hazardous product covered by the MSDS and individually meet any of the criteria defining a hazardous material. Thus, one component of a multicomponent product might be listed because of its toxicity, another component because of its flammability, while a third component could be included both for its toxicity and its reactivity. Note that a MSDS for a single component product must have the name of the material repeated in this section to avoid giving the impression that there are no hazardous ingredients.

Chemical substances should be listed according to their complete name derived from a recognized system of nomenclature. Where possible, avoid using common names and general class names such as "aromatic amine," "safety solvent," or "aliphatic hydrocarbon" when the specific name is known.

The "%" may be the approximate percentage by weight or volume (indicate basis) which each hazardous ingredient of the mixture bears to the whole mixture. This may be indicated as a range or maximum amount, ie, "10-40% vol" or "10% max wt" to avoid disclosure of trade secrets.

Toxic hazard data shall be stated in terms of concentration, mode of exposure or test, and animal used, eg, "100 ppm LC50-rat," "25 mg/kg LD50-skin-rabbit," "75 ppm LC man," or "permissible exposure from 29 CFR 1910.1000," or, if not available, from other sources of publications such as the American Conference of Governmental Industrial Hygienists or the American National Standards Institute Inc. Flashpoint, shock sensitivity,

or similar descriptive data may be used to indicate flammability, reactivity, or similar hazardous properties of the material.

(c) Section III. Physical Data

The data in Section III should be for the total mixture and should include the boiling point and melting point in degrees Fahrenheit (Celsius in parentheses); vapor pressure, in conventional millimeters of mercury (mmHg); vapor density of gas or vapor (air = 1); solubility in water, in parts/hundred parts of water by weight; specific gravity (water = 1); percent volatiles (indicated if by weight or volume) at 70 degrees Fahrenheit (21.1 degrees Celsius); evaporation rate for liquids or sublimable solids, relative to butyl acetate; and appearance and odor. These data are useful for the control of toxic substances. Boiling point, vapor density, percent volatiles, vapor pressure, and evaporation are useful for designing proper ventilation equipment. This information is also useful for design and deployment of adequate fire and spill containment equipment. The appearance and odor may facilitate identification of substances stored in improperly marked containers, or when spilled.

(d) Section IV. Fire and Explosion Data

Section IV should contain complete fire and explosion data for the product, including flashpoint and autoignition temperature in degrees Fahrenheit (Celsius in parentheses); flammable limits, in percent by volume in air; suitable extinguishing media or materials; special firefighting procedures; and unusual fire and explosion hazard information. If the product presents no fire hazard, insert "NO FIRE HAZARD" on the line labeled "Extinguishing Media."

(e) Section V. Health Hazard Information

The "Health Hazard Data" should be a combined estimate of the hazard of the total product. This can be expressed as a TWA concentration, as a permissible exposure, or by some other indication of an acceptable standard. Other data are acceptable, such as lowest LD50 if multiple components are involved.

Under "Routes of Exposure," comments in each category should reflect the potential hazard from absorption by the route in question. Comments should indicate the severity of the effect and the basis for the statement if possible. The basis might be animal studies, analogy with similar products, or human experiences. Comments such as "yes" or "possible" are not helpful. Typical comments might be:

> Skin Contact--single short contact, no adverse effects likely; prolonged or repeated contact, possibly mild irritation.
>
> Eye Contact--some pain and mild transient irritation; no corneal scarring.

"Emergency and First Aid Procedures" should be written in lay language and should primarily represent first-aid treatment that could be provided by paramedical personnel or individuals trained in first aid.

Information in the "Notes to Physician" section should include any special medical information which would be of assistance to an attending physician including required or recommended preplacement and periodic medical examinations, diagnostic procedures, and medical management of overexposed employees.

(f) Section VI. Reactivity Data

The comments in Section VI relate to safe storage and handling of hazardous, unstable substances. It is particularly important to highlight instability or incompatibility to common substances or circumstances, such as water, direct sunlight, steel or copper piping, acids, alkalies, etc. "Hazardous Decomposition Products" shall include those products released under fire conditions. It must also include dangerous products produced by aging, such as peroxides in the case of some ethers. Where applicable, shelf life should also be indicated.

(g) Section VII. Spill or Leak Procedures

Detailed procedures for cleanup and disposal should be listed with emphasis on precautions to be taken to protect employees assigned to cleanup detail. Specific neutralizing chemicals or procedures should be described in detail. Disposal methods should be explicit including proper labeling of containers holding residues and ultimate disposal methods such as "sanitary landfill" or "incineration." Warnings such as "comply with local, state, and federal antipollution ordinances" are proper but not sufficient. Specific procedures shall be identified.

(h) Section VIII. Special Protection Information

Section VIII requires specific information. Statements such as "Yes," "No," or "If necessary" are not informative. Ventilation requirements should be specific as to type and preferred methods. Respirators shall be specified as to type and NIOSH or US Bureau of Mines approval class, ie, "Supplied air," "Organic vapor canister," etc. Protective equipment must be specified as to type and materials of construction.

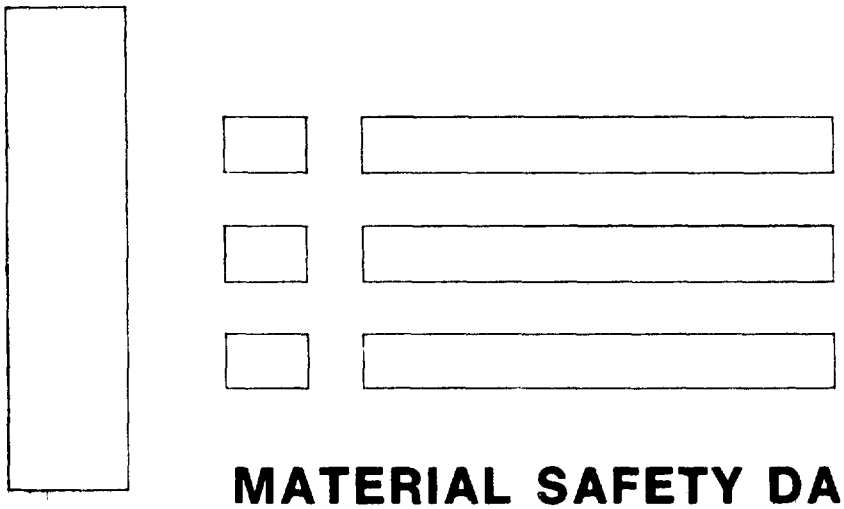
(i) Section IX. Special Precautions

"Precautionary Statements" shall consist of the label statements selected for use on the container or placard. Additional information on any aspect of safety or health not covered in other sections should be inserted in Section IX. The lower block can contain references to published guides or in-house procedures for handling and storage. Department of Transportation markings and classifications and other freight, handling, or storage requirements and environmental controls can be noted.

(j) Signature and Filing

Finally, the name and address of the responsible person who completed the MSDS and the date of completion are entered. This will facilitate correction of errors and identify a source of additional information.

The MSDS shall be filed in a location readily accessible to employees exposed to the hazardous substance. The MSDS can be used as a training aid and basis for discussion during safety meetings and training of new employees. It should assist management by directing attention to the need for specific control engineering, work practices, and protective measures to ensure safe handling and use of the material. It will aid the safety and health staff in planning a safe and healthful work environment and in suggesting appropriate emergency procedures and sources of help in the event of harmful exposure of employees.



MATERIAL SAFETY DATA SHEET

I PRODUCT IDENTIFICATION	
MANUFACTURER'S NAME	REGULAR TELEPHONE NO. EMERGENCY TELEPHONE NO.
ADDRESS	
TRADE NAME	
SYNONYMS	

II HAZARDOUS INGREDIENTS		
MATERIAL OR COMPONENT	%	HAZARD DATA

III PHYSICAL DATA			
BOILING POINT, 760 MM HG		MELTING POINT	
SPECIFIC GRAVITY (H_2O=1)		VAPOR PRESSURE	
VAPOR DENSITY (AIR=1)		SOLUBILITY IN H_2O, % BY WT	
% VOLATILES BY VOL		EVAPORATION RATE (BUTYL ACETATE=1)	
APPEARANCE AND ODOR			

IV FIRE AND EXPLOSION DATA

FLASH POINT (TEST METHOD)		AUTOIGNITION TEMPERATURE	
FLAMMABLE LIMITS IN AIR, % BY VOL.	LOWER		UPPER
EXTINGUISHING MEDIA			
SPECIAL FIRE FIGHTING PROCEDURES			
UNUSUAL FIRE AND EXPLOSION HAZARD			

V HEALTH HAZARD INFORMATION

HEALTH HAZARD DATA

ROUTES OF EXPOSURE

INHALATION

SKIN CONTACT

SKIN ABSORPTION

EYE CONTACT

INGESTION

EFFECTS OF OVEREXPOSURE

ACUTE OVEREXPOSURE

CHRONIC OVEREXPOSURE

EMERGENCY AND FIRST AID PROCEDURES

EYES

SKIN

INHALATION

INGESTION

NOTES TO PHYSICIAN

VI REACTIVITY DATA

CONDITIONS CONTRIBUTING TO INSTABILITY

INCOMPATIBILITY

HAZARDOUS DECOMPOSITION PRODUCTS

CONDITIONS CONTRIBUTING TO HAZARDOUS POLYMERIZATION

VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED

NEUTRALIZING CHEMICALS

WASTE DISPOSAL METHOD

VIII SPECIAL PROTECTION INFORMATION

VENTILATION REQUIREMENTS

SPECIFIC PERSONAL PROTECTIVE EQUIPMENT

RESPIRATORY (SPECIFY IN DETAIL)

EYE

GLOVES

OTHER CLOTHING AND EQUIPMENT

IX SPECIAL PRECAUTIONS

PRECAUTIONARY
STATEMENTS

OTHER HANDLING AND
STORAGE REQUIREMENTS

PREPARED BY _____

ADDRESS _____

DATE _____

XI. TABLES AND FIGURES

TABLE XI-1

SOME SYNONYMS AND TRADEMARKS FOR HYDROQUINONE

Arctuvin	Para-Diphenol
Para-Benzenediol	Eldoquin
1,4-Benzenediol	Hydrochinon(Czech, Polish)
Benzohydroquinone	Hydrochinone
Benzoquinol	Hydroquinol
1,4-Dihydroxy-benzeen(Dutch)	Hydroquinole
1,4-Dihydroxybenzen(Czech)	Para-Hydroquinone
Dihydroxybenzene	Para-Hydroxyphenol
Para-Dihydroxybenzene	Idrochinone(Italian)
1,4-Dihydroxybenzene	Quinol
1,4-Dihydroxybenzol(German)	Tecquinol
1,4-Diidrobenzene(Italian)	Tenox HQ
Para-Dioxybenzene	Tequinol
USAF EK-356	

Adapted from references 1,4,10,12

TABLE XI-2

ELECTRODE POTENTIALS OF SOME
REDUCTION-OXIDATION SYSTEMS

System	Potential (Volts)	pH
H2O/1/2O2	0.82	7.0
NO2-/NO3-	0.42	7.0
Cytochrome a Fe++/Fe+++	0.29	7.0
Cytochrome b Fe++/Fe+++	0.07	7.4
Cytochrome c Fe++/Fe+++	0.22	7.0
Hemoglobin/methemoglobin	0.17	7.0
Ubiquinone red/ox	0.10	7.4
Succinic acid/fumaric acid	0.03	7.0
Methylene blue red/ox	0.01	7.0
Lactic acid/pyruvic acid	-0.19	7.0
Glutathione red/ox	-0.23	7.0
Ferredoxin red/ox (algal)	-0.41	7.5
Acetaldehyde + CoA/acetyl CoA	-0.41	7.0
Acetaldehyde/acetic acid	-0.60	7.0
Alpha-ketoglutaric acid/ succinic acid + CO2	-0.67	7.0
Pyruvic acid/acetic acid + CO2	-0.70	7.0

Adapted from reference 7

TABLE XI-3

PHYSICAL AND CHEMICAL PROPERTIES OF HYDROQUINONE AND QUINONE

Property	Hydroquinone	Quinone
Molecular formula	$C_6H_4(OH)_2$	$C_6H_4O_2$
Formula weight	110.11	108.09
Appearance	Colorless to white crystalline solid	Yellow crystalline solid
Melting point	173-174 C	115.7 C
Boiling point	285 C at 730 mmHg	Sublimes
Specific gravity (water = 1.000 at 4 C)	1.332 at 15 C	1.307-1.318 at 20 C
Vapor density (air = 1)	3.81	-
Saturation concentration in air	0.108 mg/cu m (0.024 ppm)	576 mg/cu m (131 ppm)
Density of saturated air (air = 1)	1.011 at 150 C	-
Vapor pressure	0.000018 mmHg at 25 C 4 mmHg at 150 C	0.0152 mmHg at 5.3 C 0.1 mmHg at 25 C Sublimes readily upon gentle heating
Solubility	7 g/100 g water at 25 C 0.2 g/l cold benzene; soluble in isopropanol, acetone, carbon tetrachloride, ether, and other nonpolar solvents	Slightly soluble in cold water; soluble in hot water, alcohol ether, and alkalies
Flashpoint (closed cup)	165 C (329 F)	-
Autoignition temperature	516 C (960 F)	-
Conversion factors	1 mg/cu m = 0.22 ppm	1 mg/cu m = 0.23 ppm
(25 C and 760 mmHg)	1 ppm = 4.5 mg/cu m	1 ppm = 4.4 mg/cu m

Adapted from references 1,4,5,8-11

TABLE XI-4

SOME OCCUPATIONS WITH POTENTIAL EXPOSURE TO HYDROQUINONE

Ceramic decorators
Chemical Processing (using hydroquinone as an intermediate)
Drug makers
Dyemakers
Fatty oil processors
Fur dyers
Hydroquinone manufacturing workers
Lubricating-oil workers
Motor fuel blenders
Paintmakers
Photographic developer makers
Photographic laboratory workers
Plastic makers
Plastic stabilizer workers
Rubber coating workers
Stone coating workers
Styrene monomer workers
Textile coating workers
Varnish makers

Adapted from reference 40 and Fernandez (written communication, July 1977)

TABLE XI-5

SAMPLING DATA FROM A HYDROQUINONE MANUFACTURING PLANT

Sampling Location	Sample Parameters		
	Volume (Liters)	Hydro-quinone (mg)	Hydroquinone Concentration (mg/cu m)
August 1, 1974			
Drumming station, north	32.6	0.003	0.09
Drumming station, west	24.5	0.005	0.20
Drumming station, east	21.4	0.004	0.19
Operator's desk	34.7	0.006	0.17
Truck interior during loading	21.8	0.013	0.60
September 5, 1974			
Drumming station, north	60	0.014	0.31
Drumming station, west	60	0.028	0.61
Drumming station, east	60	0.016	0.35
Operator's desk	60	0.009	0.19

Adapted from reference 99(pp 87-88)

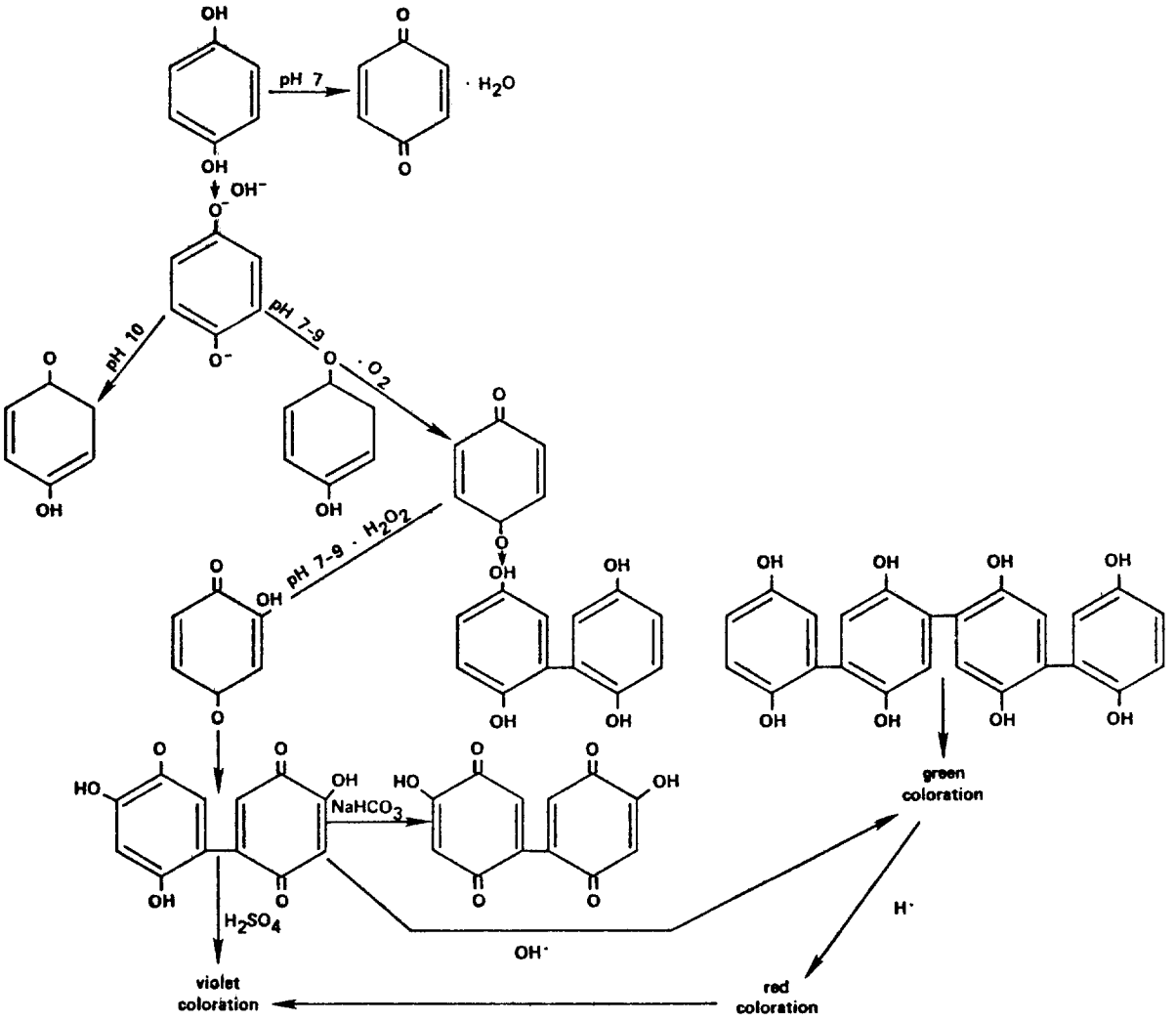


FIGURE XI-1

SUGGESTED SCHEME FOR OXIDATION OF HYDROQUINONE

Adapted from reference 18

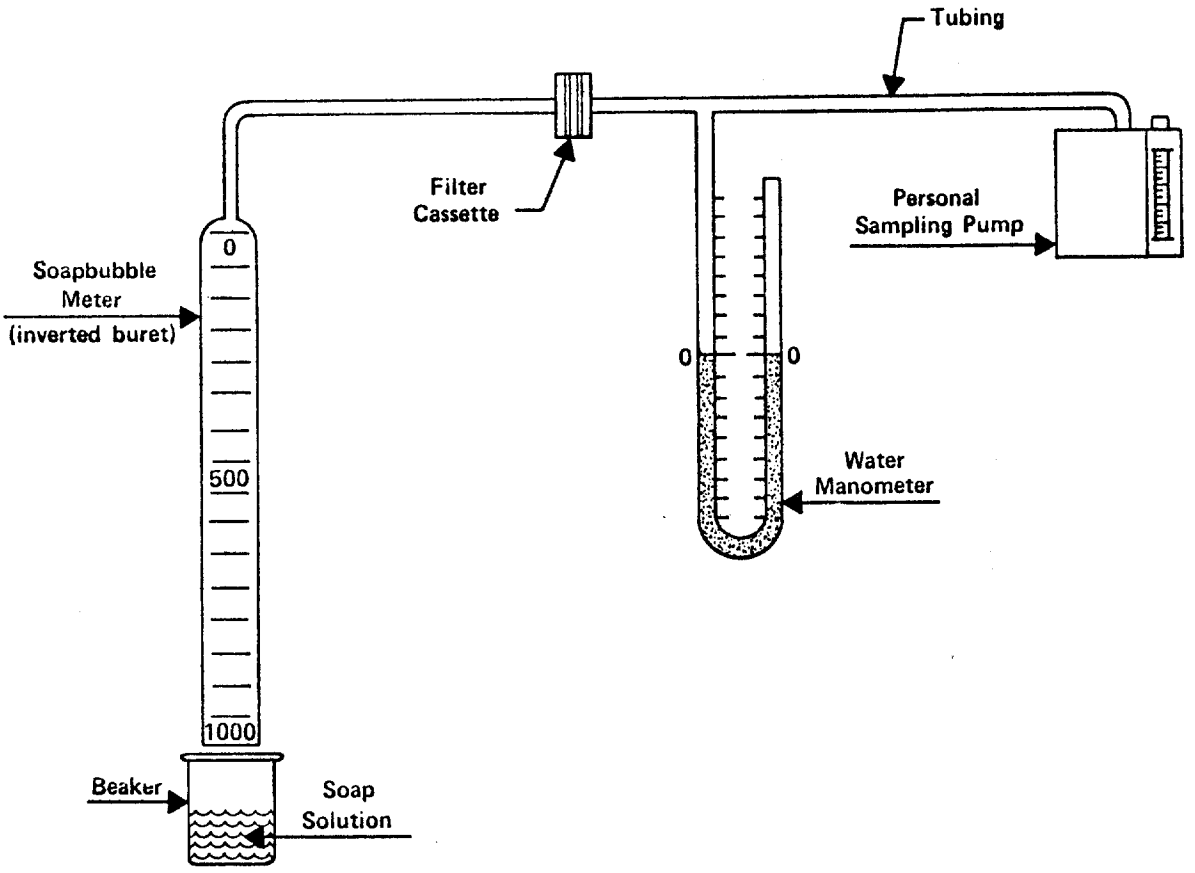


FIGURE XI-2

CALIBRATION SETUP FOR PERSONAL SAMPLING PUMP WITH FILTER CASSETTE

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DEPARTMENT OF
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NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
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