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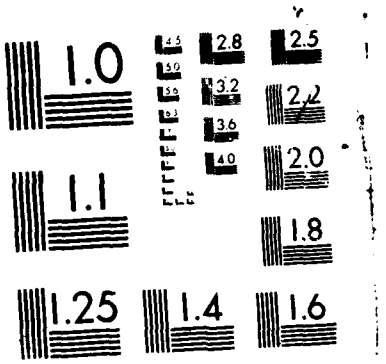

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TECHNICAL REPORT 8609

AD-A186 413

DATA SUMMARY FOR NITROCELLULOSE

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U S ARMY MEDICAL BIOENGINEERING RESEARCH & DEVELOPMENT LABORATORY
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AUGUST 1986

U.S. ARMY MEDICAL RESEARCH and DEVELOPMENT COMMAND
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The US Environmental Protection Agency (USEPA) and the Department of the Army (DA) established a cooperative agreement to develop Health Advisories (HA) on chemical substances associated with munitions that may be found as drinking water contaminants. This text summarizes information about nitrocellulose (NC) that was provided by DA to the USEPA.

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20. Abstract (continued)

NITROCELLULOSE
(CAS No. 9004-70-0) is a principal ingredient of propellants and some explosives, and is produced for military use at selected Army Ammunition Plants (AAP). It is produced by nitrating cellulose, e.g., treating cotton linters or wood pulp with mixed nitric and sulfuric acids. NC fines suspended in wastewater leave the production facility and remain suspended in receiving waters or settle on the substrate. NC measurements in waters downstream from AAP discharge have ranged up to 14 mg/L. Because of its resistance to biodegradation, it may persist in the environment and remain in aquatic sediments indefinitely.

Degradation products and metabolites from NC have not been found. NC was not absorbed by rats or dogs in metabolism studies. Toxicity has not been observed in mammals, and there is no published information about effects to humans. NC was nontoxic, LD50 >5,000 mg/kg, in acute studies with rats and mice given the chemical by intragastric intubation. Primary skin and eye irritation was not produced in rabbits. Dogs, rats, and mice given either 1 percent, 3 percent, or 10 percent NC in their feed during 13-week and 2-year studies did not develop any apparent toxic effects. Some of the mice given 10 percent NC died from impaction of the fibers in their intestines. Reproductive effects were not observed in NC-fed rats. There were no cytogenetic abnormalities seen in lymphocyte and kidney cell cultures from NC-fed rats and dogs. NC was not mutagenic in the Ames test with or without S-9 metabolic activation.

Several species of fish and benthic macroinvertebrates exposed to NC, suspended in water, at concentrations as high as 1,000 mg/L for 96 and 48 hours did not have any adverse effects. An EC50 >1,000 mg/L NC was determined for algae based on reductions in optical density, cell numbers, and chlorophyll a concentrations. Selenastrum capricornutum was the most sensitive alga studied with an EC50 of 579 mg/L NC. Habitat alteration by the NC may have caused the algal growth reduction.

NC is relatively insoluble in water and minimally toxic as evidenced by a general lack of adverse effects in animal studies. Since a minimal effects level (MEL) or no-observed-adverse-effects-level (NOAEL) apparently exceeds the maximum dose tested, 5,000 mg/kg, exposure levels were not developed or recommended in this summary. NC may have an adverse effect on drinking water quality and acceptability due to changes in overall physical characteristics such as color, taste, suspended solids, or other parameters influencing palatability.

ACKNOWLEDGMENT

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INTRODUCTION

In April 1985 the U.S. Environmental Protection Agency (USEPA) and the Department of the Army (DA) established a cooperative agreement to develop Health Advisories on chemical substances associated with munitions that may be found as drinking water contaminants within the United States and its territories.1 Health Advisories are discretionary under the authority of the Safe Drinking Water Act [para 1442(b)(1)] and normally are provided for 1-day, 10-day, and longer-term exposure periods where available toxicological data exist. The advisories provide specific advice on the levels of selected munition chemicals, in drinking water, at which adverse health effects would not be anticipated and which include margins of safety so as to protect the most sensitive members of the population at risk. Under the provisions of the cooperative agreement, the Department of the Army provides the USEPA relevant information, e.g., toxicological, environmental, and operational data, as required for the development of advisories for selected munitions.

This text summarizes information about nitrocellulose as provided by the Department of the Army to the USEPA under the provisions of the cooperative agreement. The sections titled Health Advisory Development and Conclusions are based solely on the references listed in this publication.

GENERAL INFORMATION AND PROPERTIES

Nitrocellulose (cellulose nitrate, NC) (CAS No. 9004-70-0) is a mixture of polymeric nitrate esters formed by nitrating cellulose. When the hydrogens of the three hydroxyl groups in the cellulose monomer (anhydroglucose unit) are replaced by NO_2 groups, the resulting chains of β 1 - 4 linked units form NC, represented by the formula $[C_6H_7O_2(ONO_2)_3]_n$. NC is a non-volatile, fibrous, cotton-like, white solid with a specific gravity of 1.66 and decomposition range 160°-170°C (the auto ignition temperature). It is extremely flammable, with a flashpoint of 12.8°C. The molecular weight depends on the chain length of the polymer; however, the formula weight for the trinitrated monomer unit is 297.14. NC is resistent to boiling water but can be hydrolyzed by 10 percent NaOH at 70°C to produce nitrate and nitrate ions. It decomposes in the presence of UV light as well as at temperatures above 100°C.[2]

As the result of varying conditions of nitration. e.g., acid concentration, temperature, and time, NC may contain up to 14.0 percent nitrogen. Three types of NC are recognized: pyroxylin (or collodion) with 8 to 12 percent N; pyrocellulose with 12.60 $\pm$ 0.10 percent N; and guncotton with a minimum of 13.35 percent N. Theoretically, mono- ,di-, and trinitrated cellulose contain 6.8, 11.1, and 14.1 percent N, respectively. Guncotton essentially is nitrated fully and therefore can be considered a crude cellulose trinitrate contaminated by traces of less completely nitrated

esters.[3] Blended nitrocellulose, a mixture of pyrocellulose and guncotton, also is used in propellant manufacture and has 13.15 to 13.25 percent N.

Generally the NCs are soluble in esters, aldehydes, and ketones; however, the more completely nitrated, the smaller the range of materials in which there is solubility. The less nitrated forms, i.e., pyroxylin and pyrocellulose, are also very soluble in methanol, benzene, toluene, and mixtures of ether and alcohol. Cellulose trinitrate is insoluble in water (but somewhat hygroscopic), ethanol, ethyl ether and benzene, but completely miscible with acetone, methyl-ethyl ketone, tetrahydrofuran, nitrobenzene, and ethyl-, butyl-, and amyl acetates. Cellulose trinitrate is also sparingly soluble in 2:1, ethyl ether:ethanol mixtures.[2,3]

SOURCES OF EXPOSURE

NC is a principal ingredient of propellants, smokeless powder, rocket fuel, ball powder, mortar increment, and some explosives.[2] It is produced for military use at selected Army ammunition plants (AAPs) by treating cotton linters or wood pulp with mixed nitric and sulfuric acids at 30°C. The resulting slurry is centrifuged to remove most of the acid, treated with several charges of boiling water, washed with a heavy stream of water, and finally screened to remove most of the water.[4] Production requires 16 to 22 gallons of process water per pound of NC produced. Most of this water is discharged and contains, in addition to NC, 0.7 to 1.0 pound of sulfuric acid and 0.3 to 0.4 pound of nitric acid per pound of NC produced, thus resulting in a low pH.[2,5] Military orders in FY85 called for 970,000 lb 11 6 percent N and 119,000 lb 13.5 percent N NC to be produced.[6] However, facilities exist to increase production to 82.6 million pounds.[2]

NC fines are in production wastewater because of settling pit overflow and some escape after flowing through the waste acid neutralization process lines.[7] Helton[5] analyzed samples of NC fines from wastewaters of an AAP and found that >99 percent of the particulate material was military grade NC with an average nitrogen content of 12.9 percent and particle size >5 μm. The conclusions were based upon the ability of the particles to fractionate through sieves and filters and nitro content analysis by chemical reduction. Sullivan et al.[3] interpreted these data as suggesting that the suspended solids below 0.8 microns in NC production wastewater contain significant portions of nonnitrated cellulose and other materials, and particles >44 μm are mostly NC.

Since NC is practically insoluble in water,[2,3] the fines leave the production facility suspended in the discharged wastewater and, for a time, in the receiving waters. Receiving water concentrations thus would depend upon whether the NC particles settled and on the rate of settling. Rosenblatt et al.,[2] determined that NC particles would settle at a rate of 10^{-1} cm/sec and would be transported along a surface at a minimal velocity of 1 cm/sec. This determination assumed an effective diameter of 2 μm and specific gravity of 1.65. Given this prediction, flow rate, and the quantity of NC discharged,

concentrations of NC in water along a river or stream flow route could be estimated. This method was used to predict NC concentrations along the Wisconsin and Mississippi Rivers. The NC originated from the Badger AAP (BAAP) near Baraboo, WI. In the Muscoda (Wisconsin) area, approximately 50 miles west and downstream of BAAP, maximum NC concentrations were estimated to be 0.6 mg/L (based on a 20 million gallons per day, mgd, flow rate and approximate NC discharge of 43 mg/L). Further west, approximately 100 miles from BAAP, at the confluence of the Wisconsin and Mississippi Rivers, the maximum concentration was predicted to be 0.15 mg/L (based on a combined flow rate of 5,600 mgd for the two rivers and NC discharge of 43 mg/L). In the same study NC concentrations originating from the Radford AAP (RAAP) near Radford, VA, were estimated along the New River as it flows northwest forming Bluestone Lake (West Virginia) and continues, joining the Gauley River (West Virginia), to form the Kanawha River (West Virginia). The Kanawha River ends by emptying into the Ohio River (Ohio). Along this route maximum NC concentrations were predicted to be: 1.1 mg/L between RAAP and Bluestone Lake (West Virginia); 0.7 mg/L after the Gauley River joins the New River in West Virginia, approximately 150 miles downstream from RAAP; and 0.07 mg/L after the Kanawha River empties into the Ohio River (Ohio), approximately 240 miles downstream from RAAP.

Stilwell et al.[8] described, along with other parameters, concentrations of NC measured in a system of settling ponds downstream from and associated with a wastewater treatment plant (inoperative during the study) built to process waste from BAAP. Measurements were also made at two bays downstream (northwest) from the munitions plant. NC concentrations in water ranged from <1.0 to 14.0 mg/L. Turbulence and the presence of NC fines in disturbed sediment are offered as an explanation for the higher concentrations of NC measured in the water. Sullivan et al.,[3] described low levels, 0 to 4.6 mg/L, of NC detected in water and sediment of a drainage ditch that received ammunition fabrication discharges from the Lake City AAP in Blue Spring, Missouri. The discharges flowed into the Little Blue River (Missouri).

Being resistant to biodegradation and persistent in the environment, NC in aquatic sediments may remain indefinitely.[9] Stilwell et al.[8] found sediment concentrations ranging from 17.8 to 296 mg/L near BAAP and observed that these concentrations were five to ten times greater than that found in the corresponding water. This study suggested that sediment concentrations decreased as the depth of the water column increased.

METABOLISM/PHARMACOKINETICS

Ellis et al.[10] showed that NC was not absorbed in two male rats given oral doses of ^{14}C-labeled NC for 4 days. Each rat was given 1 mL ^{14}C-nitrocellulose per 100 gm body weight (1 mL/100 gm; about 20,000 dpm/mL) suspended in either distilled water or 0.2 percent methylcellulose - 0.4 percent Tween 80 (MC-TW80) and placed immediately in a "Roth-Delmar" metabolism chamber that was vented continuously with CO_2 free air. Expired CO_2 was collected by passing the air through a series of absorption columns containing 5 percent NaOH. Feces and urine were collected separately in the chamber. Twenty-four

hours after final dosing, the rats were killed and samples of the following tissues analyzed for radioactivity: aortic blood, liver, spleen, kidneys, brain, lungs, thigh muscle, and gastrointestinal tract plus contents (stomach, small intestine, cecum, large intestine, feces). Radioactivity was detected only in the gastrointestinal tract and feces and not in any other tissue, body fluid, or expired air.

Ellis et al.[11] also fed diets containing 90 g of wet NC (27.9 g dry weight) to a dog and collected feces for 4 days. The recovered NC from feces at 1, 2, 3, and 4 days was 17.4, 4.3, 0, and 0 percent, respectively. No data were provided for the remaining NC administered.

NC has a documented resistence to both chemical hydrolysis and biological environmental degradation;[2,12] therefore, degradation products and metabolites are unknown. Rosenblatt et al.[2] and Tew and Jaffe[12] addressed a study at the US Army Natick Laboratories, Massachusetts, which sought to treat NC waste by chemical pretreatment to remove nitro groups. This pretreatment allowed subsequent biological attack by anaerobic fermentation and aerobic activated sludge; however, NC metabolites/degradation products were not described. There are no published data describing biochemical mechanisms by which NC can affect organisms.[3]

HEALTH EFFECTS

Toxic effects due to NC have not been observed in mammals, and there are no data on human toxicity.

Short-Term Exposure

Lee et al.[13] evaluated acute oral toxicity and skin and eye irritation effects of NC. Five percent NC suspended in water (dry weight basis) was administered by intragastric intubation to fasted male and female CD^{R} rats and male and female albino Swiss mice. After treatment the animals were observed for 14 days. NC was nontoxic, LD_{50} >5,000 mg/kg, in the rats and mice. Toxic signs were not observed even in animals receiving the highest doses. Two out of 10 male mice given 5,000 mg/kg died; however, there was no apparent gross lesion and no other animals died from any other dose. New Zealand rabbits were used to evaluate primary skin and eye irritation by a modified Draize test using 33 percent NC suspended in water. After application of the NC the irritation score on intact and unabraided skin and the eye was evaluated at 24 and 72 hours. NC did not produce any primary skin and eye irritation in the rabbits.

Longer-Term Exposure

Ellis et al.[10] studied the effects of feeding NC for up to 13 weeks to dogs, rats, and mice. Twenty beagle dogs were divided into five groups, each consisting of two males and two females. Three groups of dogs were given 1, 3, or 10 percent NC in their feed. A fourth group served as a vehicle control and received 10 percent cotton linters in their food to determine if any

observed effects were due to the passage of a non-nutritive bulk through the GI tract. The fifth group received moistened feed and served as a normal control. Similarly, 40 male and 40 female CD^R rats were divided into five groups, each consisting of eight males and eight females, and a total of 40 female albino Swiss mice also were grouped. The rat and mouse groups were provided the same concentration of NC in their feed as the dogs, as well as control feeds. Data collection included: weekly recording of body weight; hematology and clinical blood chemistry tests at 4, 8, 13, and/or 17 weeks in dogs and rats; hematology in mice at termination; necropsy data consisting of gross and histopathological examination of organs and tissues and weights of the heart, liver, spleen, kidneys, adrenals, pituitary, thyroid, and gonads; and plasma retention of bromosulfophthalein (BSP), also at termination. Hematology included erythrocyte and leukocyte counts, hematocrit, hemoglobin, methemoglobin, Heinz bodies, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, differential leukocyte counts, reticulocyte counts, platelet counts, and, in the dog, clotting time. Clinical blood tests included blood glucose, serum glutamic-oxaloacetic transaminase (SGOT), serum glutamic-pyruvic transaminase (SGPT), alkaline phosphatase, blood urea nitrogen (BUN), creatinine, lactate dehydrogenase (LDH), α-hydroxybutyrate dehydrogenase (α-HBDH), and creatine phosphokinase (CPK). Immunoglobin E (IgE) titers were measured by immunodiffusion techniques in which the sera of normal control and NC-fed dogs and rats were used to evaluate immunologic response to NC. At the end of 13 weeks of continuous treatment, a male and a female from each dog group, and four males and four females from each rat and mouse group, were euthanized for necropsy. Treatment for the remaining animals in the groups was discontinued, and they were studied for an additional 4 weeks to evaluate the reversibility of any adverse effects. These animals were not euthanized for necropsy; nor were there any blood studies after the additional 4 weeks of study, because there were no lesions nor adverse effects in those evaluated at 13 weeks.

Feeding up to 3 percent NC had no adverse effects. Feeding 10 percent NC increased food consumption in all species, decreased weight gain in rats and mice, and killed some mice due to impaction of the fibers in the lower intestines. The dogs decreased in weight during the first 4 weeks; however, this reversed as the study continued to completion. Feeding 10 percent cotton linters produced the same effects as 10 percent NC, so these effects were attributed to the fibers and not to the chemical nature of NC. In dogs, blood analysis revealed a number of statistically significant differences when compared with the baseline levels; however, they were small, inconsistent, and within normal limits. There were no significant changes in peripheral blood elements or clinical blood chemistry in the rats and mice. BSP was not retained in any of the experimental or control groups; nor were there any immunologic response abnormalities. NC did not cause any apparent histopathological effects or changes in organ weights.

Ellis et al.[11] studied the effects of feeding NC to dogs, rats, and mice for up to 2 by using techniques similar to those in the previous study.[10] The concentrations of NC in feed were 0 (control), 1 percent, 3 percent, and 10 percent. One group of animals was given feed containing 10 percent cotton

linters as a "cotton control." Beagle dogs, CD^R rats, and $CD\text{-}1^R$ mice were evaluated in this study using groups consisting of equal numbers of males and females. Initially there were 6 dogs, 32 rats, and 58 mice of each sex per group. A separate group of eight rats of each sex per dose group was used for a 1-year necropsy. Data collected and evaluated included: hematology and clinical chemistry tests before dosing and at the end of 3, 9, 12, 18, and 24 months; biweekly and/or weekly weights; IgE; and necropsies (gross examination, organ weights, histopathology). Recovery studies were performed after the 12- and 24-month necropsies.

The fiber-fed animals exhibited a higher feed consumption than the controls, in proportion to the fiber content; however, the rodents fed 10 percent fiber (NC or cotton linters) had a greater consumption because they separated the feed from the fiber before eating. Rats fed 10 percent fiber had lower body weights than controls, due to decreased body fats, and consequently had better survival rates. Some mice could not pass the fibers through their intestinal tracts and died from resultant impaction. A number of mice fed 10 percent fiber had transient hyperemia of the extremities, which was attributed to irritation from fibers scattered about their cages. In the 9th month of the mouse study, there was a cluster of deaths from unknown causes in the 10 percent fiber-fed group. There were three times as many deaths in the 10 percent NC-fed mice as in the cotton-fed mice. There were no toxic or pathological changes apparent from the blood chemistry tests, hemotology, histology, immune response, or cytogenetic evaluations.

Reproductive Effects

The 2-year study by Ellis et al.[11] included an additional 20 female CD^R rats in each dosage group for a three-generation reproduction study. The rats in the 10 percent fiber-fed group generally weighed less than the others. During the first two generations the 10 percent fiber pups had decreased survival during lactation because the dam could not get enough nutrition from the feed-fiber mixture. The third generation dams did adapt and had normal survival rates and pup weights.

Mutagenic Effects

NC suspended in distilled water was not mutagenic in the Ames Test with and without metabolic activation (rat liver S-9 fraction).[14] The highest NC dosage was 5,000 μg/plate. Examination of chromosomes of lymphocyte and kidney cell cultures from NC-fed rats and dogs did not reveal any apparent cytogenetic abnormalities due to NC.[10,11]

ENVIRONMENTAL (AQUATIC) TOXICITY

Bentley et al.,[15] also summarized in Sullivan et al.,[3] studied the toxicity of NC in organisms representing several different trophic levels in aquatic ecosystems.

Vertebrates

Several species of fish - Lepomis macrochirus (bluegill), Salmo gairdneri (rainbow trout), Ictalurus punctatus (channel catfish), Pimephales promelas (fathead minnow) - were exposed to NC, suspended in water, at concentrations as high as 1,000 mg/L for 48 and 96 hours. Egg, 1-hour-old fry, 7-day-old fry, 30-day-old fry, and 60-day-old fry life stages of the fathead minnow were tested to determine potential effects. Bluegills were studied in NC-containing waters under variable quality conditions including differences in temperature (15°, 20°, 25°C), hardness (35, 100, and 250 mg $CaCO_3$/L), and pH (6.0, 7.1, and 8.0). None of the fish tested exhibited adverse effects; nor were juvenile fathead minnow fish or eggs affected by NC concentrations as high as 1,000 mg/L. The bluegills, which were subjected to temperature, hardness, and pH variations in NC-containing waters, did not experience any mortality.

Invertebrates

Benthic macroinvertebrates - Daphnia magna (water flea), Gammarus fasciatus (scud), Asellus militaris (sowbug), Chironomus tentans (midge) - also were exposed to NC, suspended in water, at concentrations as high as 1,000 mg/L for 48 and 96 hours. None of these species was affected (immobolized) at these exposure levels. Therefore, EC_{50} values for NC were judged to exceed 1000 mg/L.[15] Midges were exposed to NC-containing sediment, 540 mg NC/kg, over two consecutive generations. Emergence, adult survival, and egg production of the first generation were evaluated after 10 to 15 days exposure. The second generation study was initiated with the first instar larvae originating from the first exposure. The midges did not exhibit any adverse response to NC exposure. There were no significant effects on survival or adult emergence in midges exposed to the NC-containing sediment.

Algae

Several algal species - Selenastrum capricornutum, Microcystis aeruginosa, Anabaena flos-aquae, Navicula pelliculosa - were evaluated for effects at various concentrations of NC up to 1,000 mg/L for 24-, 48-, and 96-hour durations. Based on reductions in optical density, cell numbers and chlorophyll a concentrations, M. aeruginosa, A. flos-aquae, and N. pelliculosa had EC50 >1,000 mg/L NC. S. capricornutum was the most sensitive, having a 42 percent reduction in the number of cells (per milliliter of water) and 66 percent reduction in chlorophyll a content after a 96-hour exposure to 1,000 mg/L NC. The 96-hour EC50 was calculated to be 579 mg/L NC (138 to 2,400 mg/L, 95 percent CL). Sullivan et al.[3] reported that a linear regression analysis of the Bentley mean response data would result in a 96 hr LC50 = 731 mg/L (475 to 1,039 mg/L, 95 percent CL) for S. capricornutum. Habitat alteration by NC, e.g., light attenuation[9] or sediment changes,[8] may be associated with the algal growth reduction; however, these mechanisms have not been elucidated.

HEALTH ADVISORY DEVELOPMENT

NC is insoluble in water and has not caused toxic effects in dogs, rats, and mice provided up to 10 percent NC in their daily feed for up to 2 years duration. Since a minimal effects level (MEL) or no-observed-adverse-effect-level (NOAEL) apparently exceeds the maximum dose tested, 5,000 mg/kg, exposure levels are not developed in this summary.

ANALYSIS

Rosenblatt et al.[2] summarized literature on the analysis of NC initially indicating that all analytical procedures probably would begin with collection from the water on filters. Weighing the filter is cited as a method to roughly estimate NC, but it would be limited by the presence of inert solids. Other methods cited include:

- Ferrous-titanous titration
- Ferrous sulfate titration
- NO_2 gas liberation
- Analysis of NH_3 after reduction by Devarda's alloy
- Transnitration of salicylate or citrate followed by ferrous-titanous titration
- Chromous chloride-ferric ammonium sulfate micro-determination
- Zinc dust reduction of the nitrate ester
- Hydrolytic liberation of nitrite ion in acetone

Of the detection methods listed above, the last one is the most effective for detecting low levels of NC in the environment.[2,3] It is a colorimetric method based on hydrolytic liberation of nitrite. Nitrite is liberated by OH^- from acetone solutions of nitrate esters. The resulting NO_2^- is then diazotized with either N-(naphthyl)ethylenediamine hydrochloride or α-naphthylamine and the absorbance of the solution determined at 520 to 530 nm. The reaction is not specific for NC; however, the insolubility of this compound in water allows quantitative separation of NC from NO_2^-, NO_3^-, soluble nitrate esters and other soluble nitrocompounds in mixed wastewater by filtration or dialysis. Barkley and Rosenblatt16 adapted this procedure to the Technicon Autoanalyzer. The procedure involves aspiration of a stirred NC suspension, dialysis against 9 percent saline, and hydrolysis with 5N NaOH at 70°C for 10 minutes to release nitrite ion. Sulfanilic acid is diazotized by the nitrite ion at low pH. The resulting diazonium salt is coupled with N-(1-naphthyl)ethylenediamine, and the color produced is measured at 520 nm. The limit of detectability is 0.4 mg/L. Sullivan et al.[3] outlined two methods for determining NC in sediment. The first method involves solvent extraction, with acetone or ethylacetate, of the dried sediment. The procedure is sensitive to as little as 0.5 mg/kg of nitrate ester; however, it is not specific for NC because it also extracts other organic nitrate esters and nitrocompounds. The second method involves an initial acetone extraction to isolate the nitrate ester. Nitrate is then determined colorimetrically since it will oxidize ferrous iron to ferric iron after treating the extract with

acetic acid, ferrous sulfate in sulfuric acid, and sodium sulfite. The resulting yellow color is quantified at 500 nm.

TREATMENT

Wastewater from NC production facilities is neutralized, then settled, centrifuged, and/or screened to recover NC fibers.[3] Centrifugation leads to more efficient and constant recovery due to the high specific gravity of the NC.[2] The US Army Natick Laboratories (Massachusetts) developed a chemical and microbiological process for the degradation of NC in wastewater.[2] The process involved membrane ultrafiltration of the wastewater to concentrate the suspended NC. A 200-fold concentration, to 3 to 5 percent NC suspension, was desired; however, only a 10-fold concentration, to 0.2 percent NC, was obtained in the study. The suspension was then treated with 3 percent NaOH at 90 to 95°C for 20 minutes to yield a soluble material containing little nitrate ester. After acid neutralization, nitrate ester content of the filtrate and filter extracts was determined by IR analysis to detect any undissolved nitrate ester, presumably NC. The neutralized solution was mixed with domestic wastewater and fermented anaerobically to denitrify, thus producing gaseous nitrogen as a product. Methanol could be added as a nutrient in this step. The next step was an aerobic activated sludge treatment, and finally, a second denitrification was performed, again using methanol nutrient. The product was reported to give no evidence of NC survival.

The effect of NC should be considered as it impacts on the overall physical characteristics, i.e., color, suspended solids, and dissolved solids, of the AAP wastewater.[17]

CONCLUSIONS

Nitrocellulose is relatively insoluble in water and minimally toxic, as evidenced by a general lack of adverse effects in animal studies. Nitrocellulose may have an adverse effect on drinking water quality and acceptability due to changes in overall physical characteristics such as color, taste, suspended solids, or other parameters influencing palatability.

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