Method number:	PV2122
Target concentration:	3 ppm (9.2 mg/m^3)
Procedure:	Samples are collected by drawing a known volume of air through glass sampling tubes containing XAD-2 resin coated with 10% (w/w) 1-naphthylisothiocyanate (NITC). Samples are extracted with 2 mL *N,N*-dimethylformamide (DMF) and analyzed by LC using a UV detector.
Recommended sampling time and sampling rate:	200 min at 0.1 L/min (20 L)
Reliable quantitation limit:	35 ppb
Status of method:	Partially evaluated method. This method has been subjected to established evaluation procedures of the Methods Development Team and is presented for information and trial use.

April 2003

Mary E. Eide

Methods Development Team
Industrial Hygiene Chemistry Division
OSHA Salt Lake Technical Center
Salt Lake City UT 84115-1802

1. General Discussion

1.1 Background

1.1.1 History

Air samples were received at SLTC requesting analysis for 1-amino-2-propanol (APOL) collected on tubes containing XAD-2 resin coated with 10% 1-naphthylisothiocyanate (NITC). The toxicology of APOL is similar to ethanolamine, therefore 3 ppm was used as the target concentration in this study. Ethanolamine, OSHA Method PV2111, was collected on the same tubes, so the analytical parameters were used as a starting point[1]. The extraction and retention studies were performed using the Bakerbond CN LC column with a mobile phase of 90:10 isooctane:isopropanol. The quantitation was performed at 280 nm because the *N,N*-dimethylformamide (DMF) peak did not respond much at this wavelength and therefore did not interfere with the integration of the APOL peak. This column became irreparably clogged and could not be replaced soon, therefore a Restek Pinnacle TO-11 LC column and a mobile phase of 55:45:0.2 acetonitrile:water:phosphoric acid was used for the remaining tests. The peak shape on the TO-11 column was sharper, giving greater sensitivity. The samples were extracted with 2 mL DMF, and had good extraction efficiencies averaging 99.6%. The retention efficiency study showed no APOL on the back up section of the spiked tube or back up tube, for tubes spiked with 308 µg, that had 20 L humid air drawn through them. The storage study showed little loss for samples stored for up to 14 days under both refrigerated and ambient conditions.

1.1.2 Toxic effects (This section is for information only and should not be taken as the basis of OSHA policy.) [2,3]

APOL is a moderate skin irritant, severe eye irritant, and moderate mucous membrane irritant. It is moderately toxic by ingestion and mucous membrane absorption. It is a poison by intraperitoneal route. It causes a delayed pulmonary edema, 4-6 hours after exposure, resulting in chemical pneumonia.

1.1.3 Workplace exposure[4,5]

APOL is used as an emulsifying agent, in dry-cleaning soaps, soluble textile oils, wax removers, metal cutting oils, cosmetics, emulsion paints, plasticizers, and insecticides. National Occupational Exposure Survey (1981-1983) found about 132,873 American workers potentially exposed to APOL.

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1 OSHA Sampling and Analytical Methods. http://www.osha.gov (accessed 3/25/2003).

2 Lewis, R., *Sax's Dangerous Properties of Industrial Materials,* Van Nostrand Reinhold: New York, 2002, p 212.

3 International Chemical Safety Card. http://www.cdc.gov/niosh (accessed 3/25/2003).

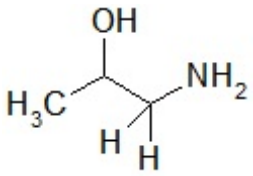
4 Lewis, R., Ed, *Hawley's Condensed Chemical Dictionary,* John Wiley & Sons: New York, 2001, p 628.

5 National Occupational Exposure Survey (1981-1983). http://www.cdc.gov/noes1 (accessed 3/25/2003).

1.1.4 Physical properties and other descriptive information[6,7]

CAS number:	78-96-6	IMIS[8]:	A606
molecular weight:	75.13	vapor density:	2.6
melting point:	1.4°C	boiling point:	159.9°C
appearance:	clear liquid	vapor pressure:	0.0013 kPa @20°C
odor:	mild ammoniacal	flash point:	77°C (165 °F)(cc)
autoignition		density:	0.9619
temperature:	374°C (705°F)	molecular formula:	C_3H_9NO
solubility:	water, alcohol, acetone		
synonyms:	1-aminopropan-2-ol; 2-hydroxypropylamine; isopropanolamine; threamine		

structural formula:



This method was evaluated according to the OSHA SLTC "Evaluation Guidelines for Air Sampling Methods Utilizing Chromatographic Analysis"[9]. The Guidelines define analytical parameters, specify required laboratory tests, statistical calculations and acceptance criteria. The analyte air concentrations throughout this method are based on the recommended sampling and analytical parameters.

1.2 Detection limit of the overall procedure (DLOP) and reliable quantitation limit (RQL)

The DLOP is measured as mass per sample and expressed as equivalent air concentrations, based on the recommended sampling parameters. Ten samplers were spiked with equal descending increments of analyte, such that the highest sampler loading was 9.2 µg of APOL. This is the amount spiked on a sampler that would produce a peak at least 10 times the response for a sample blank. These spiked samplers were analyzed with the recommended analytical parameters, and the data obtained used to calculate the required parameters (standard error of estimate (SEE) and slope) for the calculation of the DLOP. The slope was 1.67×10^4 and the SEE was 3572. The RQL is considered the lower limit for precise quantitative measurements. It is determined from the regression line parameters obtained for the calculation of the DLOP, providing 75% to 125% of the analyte is recovered. The DLOP and RQL were 0.64 µg and 2.14 µg, respectively. The recovery at the RQL was 99.3%.

6 Lewis, R., *Sax's Dangerous Properties of Industrial Materials,* Van Nostrand Reinhold: New York, 2002, p 212.

7 Lewis, R., Ed, *Hawley's Condensed Chemical Dictionary,* John Wiley & Sons: New York, 2001, p 628.

8 OSHA Chemical Sampling Information http://www.osha.gov (accessed 3/25/2003).

9 Burright, D.; Chan, Y.; Eide, M.; Elskamp, C.; Hendricks, W.; Rose, M. C. *Evaluation Guidelines for Air Sampling Methods Utilizing Chromatographic Analysis*; OSHA Salt Lake Technical Center, U.S. Department of Labor: Salt Lake City, UT, 1999.

Table 1.2
Detection Limit of the Overall Procedure for APOL

mass per sample (µg)	area counts (µV-s)
0.00	4170
0.92	20235
1.84	36189
2.76	48602
3.68	65229
4.60	80445
5.52	95767
6.44	119654
7.36	132564
8.28	139170
9.2	154875

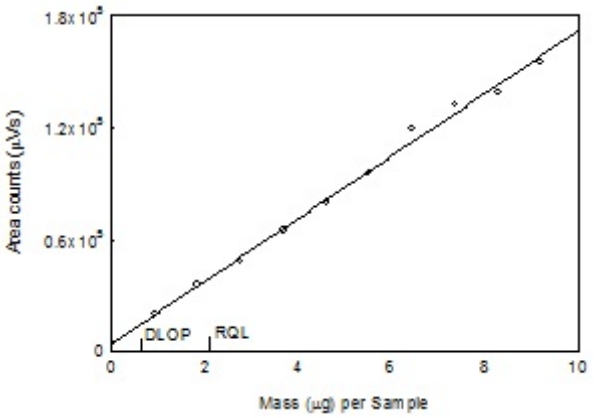


Figure 1.2.1. Plot of data to determine the DLOP/RQL for APOL at 280 nm using a TO-11 column. ($y = 1.67 \times 10^4 x + 4666$; SEE = 3572)

Below are the chromatograms of the RQL level.

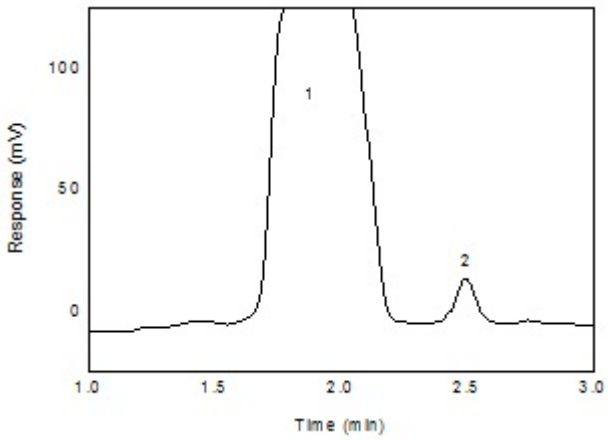


Figure 1.2.2. Chromatogram of the APOL peak in a standard near the RQL at 254 nm using a TO-11 column. Key: (1) DMF; (2) APOL

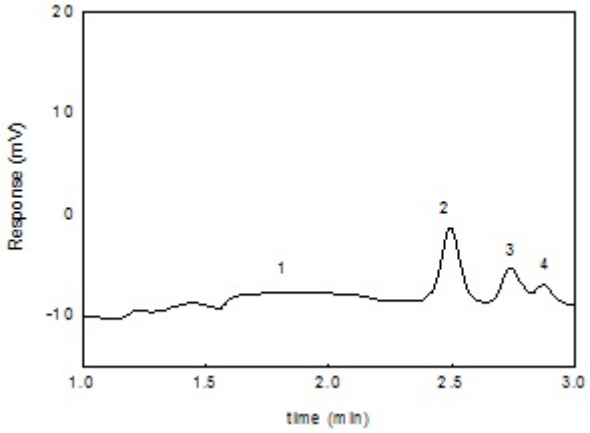


Figure 1.2.3. Chromatogram of the APOL peak in a standard near the RQL at 280 nm using a TO-11 column. Key: (1) DMF; (2) APOL; (3) & (4) interferences from NITC.

2. Sampling Procedure

All safety practices that apply to the work area being sampled should be followed. The sampling equipment should be attached to the worker in such a manner that it will not interfere with work performance or safety.

2.1 Apparatus

2.1.1 Samples are collected using a personal sampling pump calibrated, with the sampling device attached, to within ±5% of the recommended flow rate.

2.1.2 Samples are collected with 7-cm × 4-mm i.d. × 7-mm o.d. glass sampling tubes packed with two sections (80/40 mg) of XAD-2 resin coated with 10% by weight 1-naphthylisothiocyanate. The sections are held in place and separated with a glass wool plugs. For this evaluation, commercially prepared sampling tubes were purchased from SKC, Inc. (catalog no. 226-30-18).

2.2 Reagents

None required.

2.3 Technique

2.3.1 Immediately before sampling, break off the ends of the flame-sealed tube to provide an opening approximately half the internal diameter of the tube. Wear eye protection when breaking ends. Use tube holders to minimize the hazard of broken glass. All tubes should be from the same lot.

2.3.2 The smaller section of the adsorbent tube is used as a back-up and is positioned nearest the sampling pump. Attach the tube holder to the sampling pump so that the adsorbent tube is in an approximately vertical position with the inlet facing down during sampling. Position the sampling pump, tube holder and tubing so they do not impede work performance or safety.

2.3.3 Draw the air to be sampled directly into the inlet of the tube holder. The air being sampled is not to be passed through any hose or tubing before entering the sampling tube.

2.3.4 After sampling for the appropriate time, remove the adsorbent tube and seal it with plastic end caps. Seal each sample end-to-end with an OSHA-21 form as soon as possible.

2.3.5 Submit at least one blank sample with each set of samples. Handle the blank sample in the same manner as the other samples except draw no air through it.

2.3.6 Record sample air volumes (liters), sampling time (minutes) and sampling rate (L/min) for each sample, along with any potential interferences on the OSHA-91A form.

2.3.7 Submit the samples to the laboratory for analysis as soon as possible after sampling. If delay is unavoidable, store the samples at refrigerator temperature. Ship any bulk samples separate from the air samples.

2.4 Extraction efficiency

The extraction efficiency was determined by spiking NITC-coated XAD-2 tubes with APOL at 0.1 to 2 times the target concentration. These samples were stored overnight at ambient temperature and then extracted for 30 minutes with shaking, and analyzed. The mean extraction efficiency over the studied range was 99.6%. The wet extraction efficiency was determined at 1 times the target concentration by spiking the analyte onto NITC-coated XAD-2 tubes which had 20-L humid air (absolute humidity of 15.9 mg/L of water, about 80% relative humidity at 22.2 °C) drawn through them immediately before spiking. The mean recovery for the wet samples was 99.1%.

Table 2.4
Extraction Efficiency (%) of APOL

level		sample number						
× target concn	µg per sample	1	2	3	4	5	6	mean
0.1	18.4	100.6	98.6	98.5	99.9	99.0	100.1	99.5
0.25	46	98.9	99.9	100.5	98.7	99.1	100.2	99.6
0.5	92	97.4	99.2	100.4	99.1	98.3	100.2	99.1
1.0	184	100.8	99.9	99.5	100.3	99.3	99.7	99.9
1.5	276	99.8	98.9	99.3	100.4	99.9	98.9	99.5
2.0	368	100.8	99.3	99.9	100.2	98.7	100.5	99.9
1.0 (wet)	184	100.0	98.9	99.2	98.5	98.7	99.0	99.1

2.5 Retention efficiency

Six NITC-coated XAD-2 tubes were spiked with 368 µg (6.0 ppm) of APOL and allowed to equilibrate for 4 h. Each spiked tube was placed in series with a second NITC-coated XAD-2 tube. Each sampling train had 20-L humid air (absolute humidity of 15.9 mg/L of water, about 80% relative humidity at 22.2 °C) pulled through them at 0.1 L/min. The samples were extracted and analyzed. The mean recovery was 99.4%. There was no analyte found on the backup section of any of the tubes or on the second, backup tube.

Table 2.5
Retention Efficiency (%) of APOL

	sample number						
section	1	2	3	4	5	6	mean
front of spiked tube	98.9	99.5	100.1	98.8	99.9	99.3	99.4
rear of spiked tube	0.0	0.0	0.0	0.0	0.0	0.0	0.0
front of series tube	0.0	0.0	0.0	0.0	0.0	0.0	0.0
back of series tube	0.0	0.0	0.0	0.0	0.0	0.0	0.0
total	98.9	99.5	100.1	98.8	99.9	99.3	99.4

2.6 Sample storage

Fifteen NITC-coated XAD-2 tubes were each spiked with 184 µg (3.0 ppm) of APOL. They were allowed to equilibrate for 4 h, then 20 L of air, with an absolute humidity of 15.7 milligrams of water per liter of air (about 80% relative humidity at 23 °C), was drawn through them. Three samples were analyzed immediately, and the rest were sealed. Six were stored at room temperature (23 °C), while the other six were stored at refrigerated temperature (4 °C). Three samples stored at room temperature and three samples stored at refrigerated temperature were analyzed after 7 days and the remaining three after 14 days. The amounts recovered, indicate good storage stability for the time period studied.

Table 2.6
Storage Test APOL

time	ambient storage recovery (%)			refrigerated storage recovery (%)		
(days)						
0	100.1	99.5	98.5	100.1	99.5	98.5
7	99.8	99.0	98.6	98.9	99.8	99.1
14	99.1	98.9	99.7	99.7	99.0	98.3

2.7 Recommended air volume and sampling rate

Based on the data collected in this evaluation, 20-L air samples should be collected at a sampling rate of 0.1 L/min for 200 minutes.

2.8 Interferences (sampling)

2.8.1 There are no known compounds which will severely interfere with the collection of APOL. Other primary and secondary amines will collect on this media, and form derivatives with the NITC, affecting the ability of the tube to collect APOL, so sampling time should be adjusted if high concentrations of amines are expected.

2.8.2 Suspected interferences should be reported to the laboratory with submitted samples.

3. Analytical Procedure

Adhere to the rules set down in your Chemical Hygiene Plan. Avoid skin contact and inhalation of all chemicals and review all appropriate MSDSs.

3.1 Apparatus

3.1.1 A liquid chromatograph equipped with a UV detector. For this evaluation, a Waters 600 controller and pump were used, with a Waters 2487 dual wavelength absorbance detector, and a Waters 717 plus autosampler was used in this evaluation.

3.1.2 An LC column capable of separating APOL from the desorption solvent, interferences in the NITC, and any potential interferences. A 4.6 × 250 cm column packed with 5µ Bakerbond cyanopropyl (JT Baker, Phillipsburg, NJ), and a 4.6 × 250 cm column packed with 5µ Pinnacle TO-11 (Restek, Bellefonte, PA) were used in the evaluation.

3.1.3 An electronic integrator or some other suitable means of measuring peak areas. A Waters Millennium[32] Data System was used in this evaluation.

3.1.4 Glass vials with poly(tetrafluoroethylene)-lined caps. For this evaluation 4-mL vials were used.

3.1.5 A dispenser capable of delivering 2.0 mL of desorbing solvent to prepare standards and samples. If a dispenser is not available, a 2.0-mL volumetric pipet may be used.

3.1.7 Volumetric flasks - 10-mL and other convenient sizes for preparing standards.

3.2 Reagents

3.2.1 1-Amino-2-propanol. Aldrich lot 03417PU 93% (7% 2-amino-1-propanol) was used in this evaluation.

3.2.2 *N,N*-Dimethyl formamide, reagent grade. Fisher 99.5%+ (lot 933764) was used for this evaluation.

3.2.3 1-Naphthylisothiocyanate, reagent grade. Aldrich 95%+ (lot 09925MY) was used in this evaluation.

3.2.4 Isopropyl alcohol, HPLC grade. Fisher 99.9% (lot 022995) was used in this evaluation.

3.2.5 Isooctane, HPLC grade. Fisher 99.0%+ (lot 025050) was used in this evaluation.

3.2.6 Acetonitrile, HPLC grade. Fisher 99.9%+ (lot 023721) was used in this evaluation.

3.2.7 Deionized water (DI water). A Barnstead NANOpure Diamond water deionizer was used in this evaluation.

3.2.8 Phosphoric acid, Baker Analyzed Reagent grade. Baker 85.9% (lot D25821) was used in this evaluation.

3.2.9 Mobile phase for the normal phase analysis using the Bakerbond CN column was 95:5 isooctane:isopropyl alcohol.

3.2.10 Mobile phase for the reverse phase analysis using the Restek Pinnacle TO-11 column was 50:50:0.2 acetonitrile:water:phosphoric acid.

3.3 Standard preparation

3.3.1 Prepare two stock standards. A stock standard of a concentration of 2 mg/mL may be prepared by weighing out about 50 mg of NITC in a 10-mL flask, then weigh out 20 mg APOL placing the drops on top of the NITC in the flask, then weigh out about 50 mg more NITC on top of the APOL. Allow the amine to react with the NITC for 10 minutes (if other aliphatic amines are being prepared at the same time it is necessary to allow them to react

1 hour, other alcohol amines take 10 minutes). Partially fill the volumetric flask with DMF and allow to sit at least 10 minutes to dissolve the derivative, swirl to dissolve, and fill to the mark with DMF. Do not place the flask in a sonic bath to try to get the derivative to go into solution, as this will destroy the derivative. There must always be an excess of the NITC for the derivative to be completely formed. There is one amine group which will react with the NITC, so this mole ratio must be used in calculating the amount of NITC to be added. For example, the amount of NITC needed for the above stock standard would be calculated:

20 mg APOL × (NITC MW=185.25/APOL MW=75.13) = 49.3 mg NITC

In the above stock standard preparation a total of 100 mg NITC was weighed out so that an excess of NITC was present.

3.3.2 Diluted standards are prepared with a solution of 1 mg/mL NITC in DMF, so that an excess of NITC is always present. Bracket sample concentrations with working standard concentrations. If sample concentrations are higher than the concentration range of prepared standards, either analyze higher standards, or dilute the sample. The higher standards should be at least as high in concentration as the highest sample. Diluted samples should be prepared with a solution of 1 mg/mL NITC in the DMF. The range of standards used in this study was from 0.5 to 368 µg/mL.

3.4 Sample preparation

3.4.1 Remove the plastic end caps from the sample tubes and carefully transfer the adsorbent sections to separate 4-mL vials. Discard the glass tube, urethane foam plug and glass wool plug.

3.4.2 Add 2.0 mL of DMF to each vial using the same dispenser as used for preparation of standards.

3.4.3 Immediately seal the vials with poly(tetrafluoroethylene)-lined caps.

3.4.4 Shake the vials on a shaker for 30 minutes.

3.5 Analysis

3.5.1 Liquid chromatograph conditions.

LC conditions normal phase

column:	Bakerbond cyanopropyl (CN) 5-µ column 4.6 × 250 cm
injection size:	10 µL
mobile phase:	2 mL/min 95:5 isooctane: isopropyl alcohol
detector:	UV at 254 and 280 nm
run time:	10 min
retention times:	1.98 min NITC; 4.63 min DMF (at 280 nm this peak is minimal); 6.09 min APOL

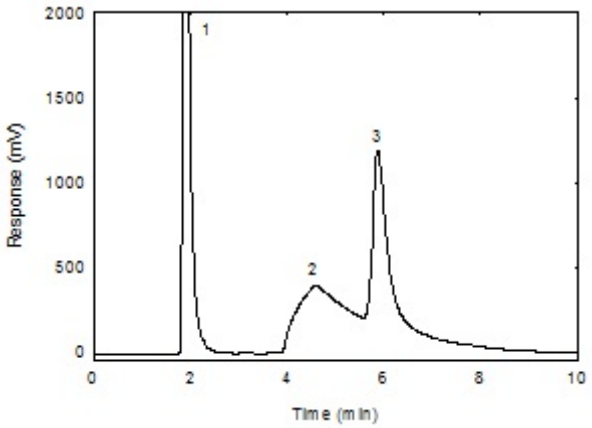


Figure 3.5.1.1. A chromatogram of 184 µg/mL APOL in DMF with NITC at 254 nm using a Bakerbond CN column. Key: (1) NITC; (2) DMF; (3) APOL.

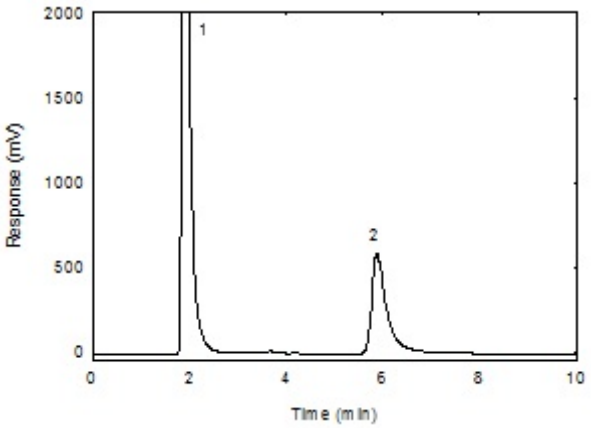


Figure 3.5.1.2. A chromatogram of 184 µg/mL APOL in DMF with NITC at 280 nm using a bakerbond CN column. Key: (1) NITC; (2) APOL.

LC conditions reverse phase

column:	Restek Pinnacle TO-11 5-µ column, 4.6 × 250 cm
injection size:	10 µL
mobile phase:	1.5 mL/min 50:50:0.2 acetonitrile:water:phosphoric acid
detector:	UV at 254 and 280 nm
run time:	14 min
retention times:	1.92 min DMF (at 280 nm this peak is minimal); 2.49 min APOL; 30.4 min NITC

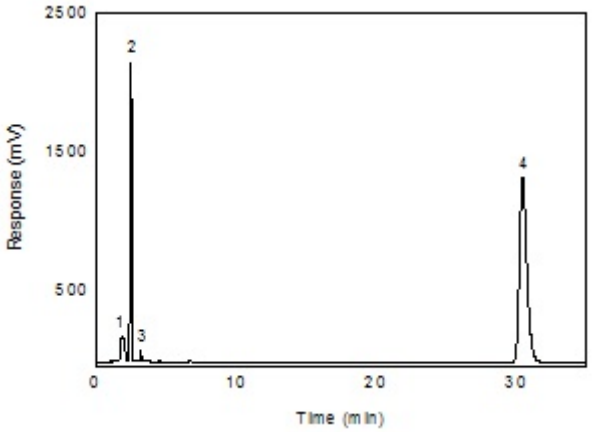


Figure 3.5.1.3. A chromatogram of 184 µg/mL APOL in DMF with NITC at 254 nm using a TO-11 column. Key: (1) DMF; (2) APOL; (3) interference from NITC; (4) NITC.

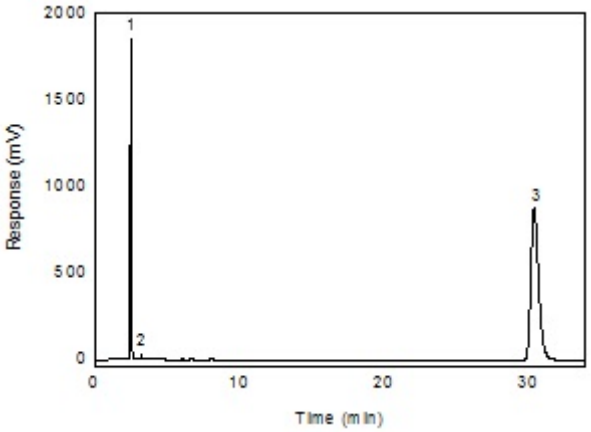


Figure 3.5.1.4. A chromatogram of 184 µg/mL APOL in DMF with NITC at 280 nm using a TO-11 column. Key: (1) APOL; (2) interference from NITC; (3) NITC.

3.5.2 Peak areas are measured by an integrator or other suitable means.

3.5.3 An external standard (ESTD) calibration method is used. A calibration curve can be constructed by response of standard injections versus micrograms of analyte per sample. Bracket the samples with freshly prepared analytical standards over a range of concentrations.

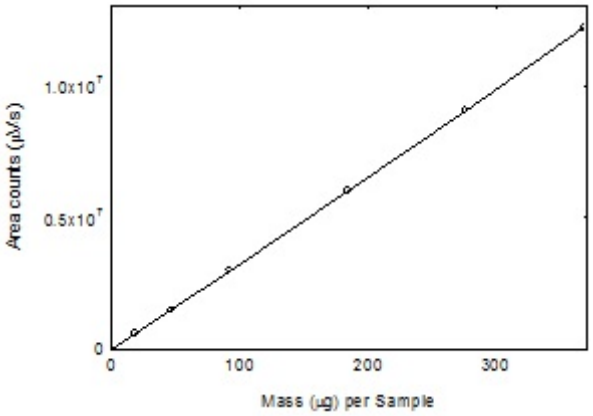


Figure 3.5.3. Calibration curve of APOL at 280 nm on TO-11 column. ($Y = 3.31\times10^4 \text{ x} - 2.98\times10^4$).

3.6 Interferences (analytical)

3.6.1 Any compound that produces a LC response and has a similar retention time as the analyte is a potential interference. If any potential interferences were reported, they should be considered before samples are extracted. Generally, chromatographic conditions can be altered to separate an interference from the analyte.

3.6.2 When necessary, the identity or purity of an analyte peak may be confirmed by a photodiode array scan of the peak, by wavelength ratioing, or by LC-mass spec.

3.7 Calculations

The amount of analyte per sampler is obtained from the appropriate calibration curve in terms of micrograms per sample, uncorrected for extraction efficiency. This total amount is then corrected by subtracting the total amount (if any) found on the blank. The air concentration is calculated using the following formulas.

$$C_M = \frac{M}{VE_E}$$

where C_M is concentration by weight (mg/m^3)
M is micrograms per sample
V is liters of air sampled
E_E is extraction efficiency, in decimal form

$$C_V = \frac{V_M C_M}{M_r}$$

where C_V is concentration by volume (ppm)
V_M is molar volume at 25 °C and 1 atm = 24.46
C_M is concentration by weight
M_r is molecular weight = 75.13

4. Recommendations for further study

Collection, reproducibility, and other detection limit studies need to be performed to make this a validated method.