

PALLADIUM IN FRESH AND SPENT ALUMINA CATALYST BY SPECTROPHOTOMETRY

UOP Method 917-93

SCOPE

This method is for determining palladium in fresh and spent silica-free alumina catalyst over a range of approximately 0.2 to 1 mass-%. Components, such as platinum and iridium, that produce colored ions with iodide and absorb at approximately 408 nm constitute an interference and, therefore, catalysts that contain such components cannot be analyzed.

OUTLINE OF METHOD

A representative portion of fresh catalyst is ground and appropriately sampled for analysis. Spent catalyst must be dried and ignited at 900°C until it is carbon free prior to grinding and sampling. A representative portion of the ground catalyst is treated with sulfuric, phosphoric, hydrochloric and nitric acids until all of the alumina is dissolved and sulfur trioxide, SO₃, fumes are observed. Hydrochloric acid and hydrogen peroxide are added to redissolve the palladium.

An aliquot of the catalyst solution is reacted with an excess of potassium iodide in a solution containing sodium sulfite to form a stable chromophore. The absorbance is measured at 408 nm and the palladium concentration is determined by comparing the absorbance of the sample solution to a standard calibration curve prepared from matrix-matched standard palladium solutions. The palladium concentration of fresh and spent catalyst is corrected to a volatile-free basis based on a loss on ignition (LOI) according to UOP Method 275.

APPARATUS

References to catalog numbers and suppliers are included as a convenience to the method user. Other suppliers may be used.

Balance, electronic, readability 0.1-mg, 200-g capacity

Balance, electronic, top-loading, readability 0.001-g, 210-g capacity

Balance, electronic, top-loading, readability 0.01-g, 2000-g capacity

Beakers, Griffin, borosilicate glass, with spout, 50-, 250-, 400- and 2000-mL, Fisher Scientific, Cat. Nos. 02-540G, -540K, -540L and -540R, respectively

IT IS THE USER'S RESPONSIBILITY TO ESTABLISH APPROPRIATE PRECAUTIONARY PRACTICES AND TO DETERMINE THE APPLICABILITY OF REGULATORY LIMITATIONS PRIOR TO USE. EFFECTIVE HEALTH AND SAFETY PRACTICES ARE TO BE FOLLOWED WHEN UTILIZING THIS PROCEDURE. FAILURE TO UTILIZE THIS PROCEDURE IN THE MANNER PRESCRIBED HEREIN CAN BE HAZARDOUS. MATERIAL SAFETY DATA SHEETS (MSDS) OR EXPERIMENTAL MATERIAL SAFETY DATA SHEETS (EMSDS) FOR ALL OF THE MATERIALS USED IN THIS PROCEDURE SHOULD BE REVIEWED FOR SELECTION OF THE APPROPRIATE PERSONAL PROTECTION EQUIPMENT (PPE).

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UOP Methods are available through ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken PA 19428-2959, United States. The Methods may be obtained through the ASTM website, www.astm.org, or by contacting Customer Service at service@astm.org, 610.832.9555 FAX, or 610.832.9585 PHONE.

Bottle, narrow-mouth, round, amber glass, 237-mL, with molded plastic conical polyethylene-lined cap, Fisher Scientific, Cat. No. 03-320-6C

Bottle, polyethylene, right-to-know safety wash, distilled water, 500-mL, Fisher Scientific, Cat. No. 03-409-11E

Bulbs, dropper, for Pasteur pipet, Fisher Scientific, Cat. No. 13-678-9A

Buret, weighing, 10-mL, Kimble No. 17200F-10, Baxter Scientific Products, Cat. No. B9366-10

Calculator, capable of least squares analysis

Cell, spectrophotometric, 10-mm path length, near-UV glass, rectangular, universally matched, Fisher Scientific, Cat. No. 14-385-910A, or a flow cell to fit the spectrophotometer (see Note 1)

Crucible, low, wide-form, porcelain, 30-mL, with cover, Fisher Scientific, Cat. Nos. 07-955E and 07-970G, respectively

Cylinders, graduated, borosilicate glass, 10-, 25-, 50-, 100- and 250-mL

Cylinder, graduated, plastic, polypropylene, 50-mL

Desiccator, with plate, Fisher Scientific, Cat. Nos. 08-631B and 08-641C, respectively

Flask, Kjeldahl, 100-mL, Fisher Scientific, Cat. No. 10-110C

Flasks, volumetric, Class A, 100-, 200-, 250-, 500- and 1000-mL

Hot plate, stirring, with Pyrocera glass ceramic top, Fisher Scientific, Cat. No. 11-495-29

Pipets, Mohr, Class B, 5-, 10- and 25-mL, Fisher Scientific, Cat Nos. 13-664F, G and H, respectively

Pipet, Pasteur, controlled drop, Fisher Scientific, Cat. No. 13-678-30

Pipets, volumetric transfer, Class A, 5-, 10-, 15- and 50-mL

Scoop, weighing, 20-g capacity, nickel alloy, Fisher Scientific, Cat. No. 01-914-38

Spatula, ellipso-spoon, 30-cm, Fisher Scientific, Cat. No. 14-375-57

Spectrophotometer, minimum spectrophotometric repeatability of ± 0.0003 at 0.1 Abs, noise less than 0.00005 Abs (rms) at 0.0 Abs, and 0.0006 Abs (rms) at 2.0 Abs, minimum stability of 0.0003 Abs per hour, readability to 0.0001 Abs, Varian Instrument Group, Cary Model 4 (Note 2)

Standards, absorbance, spectrophotometric, certified, glass-filters, 10-30% transmittance, 440- to 635-nm wavelength range, National Institute of Standards and Technology, Cat. No. SRM-930-D

Stirrer, magnetic, Fisher Scientific, Cat. No. 11-495-28

Stirring bars, magnetic, borosilicate glass, 6-mm OD x 21-mm, and 9.55-mm OD x 25.4-mm, Baxter Scientific Products, Cat. Nos. S8313-31 and -33, respectively

Stirring bar, magnetic, quartz, Alnico magnet, 10-mm OD x 35- to 40-mm, Pyromatics, Cat. No. PI-8789 (optional)

Stirring rod, borosilicate glass, Baxter Scientific Products, Cat. No. S8205-2

Thermometer, surface, with temperature probe, Omega Engineering, Cat. Nos. HH81 and 88108K, respectively

Tongs, beaker

Watch glass, borosilicate glass, ribbed, 100-mm diameter, Fisher Scientific, Cat. No. 02-613B

REAGENTS AND MATERIALS

All reagents shall conform to the specifications established by the Committee on Analytical Reagents of the American Chemical Society, when such specifications are available, unless otherwise specified. References to water mean deionized or distilled water, except where noted.

References to catalog numbers and suppliers are included as a convenience to the method user. Other suppliers may be used.

Alumina, catalyst support, UOP

Catalyst support solution, 4 mass/vol-%. Prepare in a 2-L beaker by dissolving 40 g of catalyst support in 400 mL of phosphoric acid, 400 mL of sulfuric acid and 100 mL of water on a hot plate while stirring. Allow to cool to ambient temperature and quantitatively transfer to a 1-L volumetric flask with water. Dilute to the mark with water and mix well. The catalyst support solution may be stored indefinitely in a well stoppered bottle or flask.

Desiccant, indicating Drierite, 8 mesh, Fisher Scientific, Cat. No. 07-578-3A

Hydrochloric acid, concentrated, 37%

Hydrogen peroxide, concentrated, 30%

Lens paper, optical, Fisher Scientific, Cat. No. 11-996

Nitric acid, concentrated, 70%

Palladium wire, 0.25-mm diameter, high purity 99.997%, Aesar, Cat. No. 10962

Phosphoric acid, concentrated, 85%

Potassium iodide, free flowing, granular, Fisher Scientific, Cat. No. P410

Potassium iodide-sodium sulfite, solution. Dissolve 100 ± 0.01 g of potassium iodide in 100 mL of water in a 250-mL beaker. Quantitatively transfer to a 200-mL volumetric flask with water. Pipet 10 mL of 1.2% sodium sulfite solution into the 200-mL volumetric flask. Fill to the mark with water, stopper and mix well. Prepare daily or each day used.

Sodium sulfite, anhydrous, granular, Fisher Scientific, Cat. No. S433

Sodium sulfite, approximately 1.2% solution. Dissolve 1.20 ± 0.01 g of sodium sulfite in 50 mL of water in a 100-mL volumetric flask. Dilute to the mark with water, stopper and mix well. Prepare daily or each day used.

Sulfuric acid, concentrated, 98%

Sulfuric acid, 1:1. Carefully, and with ice-cooling, pour 500 mL of concentrated sulfuric acid into 500 mL of water, mix and allow to cool. The sulfuric acid may be stored indefinitely in a well stoppered bottle or flask.

Test paper, potassium iodide-starch, Fisher Scientific, Cat. No. 14-860

STANDARD PREPARATION

All subsequent steps involving handling and heating of concentrated acids or acid solutions must be performed in a fume hood.

1. Weigh 1.0 g of 99.997% palladium wire to the nearest 0.1 mg.

2. Transfer the palladium wire into a 100-mL Kjeldahl flask and add a small borosilicate glass magnetic stir bar.
3. Add 25 mL of hydrochloric acid and 10 mL of nitric acid to the flask. Place the flask in a 400-mL beaker.
 - Treatment of the palladium is conducted at ambient temperature until evolution of chlorine has subsided.
 - If allowed to sit overnight, the palladium wire may dissolve without heating.
4. Place the flask and beaker on a stirring hot plate and heat to a gentle boil while stirring slowly.
5. Maintain the solution volume at approximately 30 mL by the dropwise addition of concentrated nitric and hydrochloric acid in a ratio of 2 to 5, respectively, until the palladium wire dissolves.
 - Caution must be exercised during the addition of the acids to avoid spattering of the palladium solution.
6. Evaporate the acid solution slowly to approximately 20 mL by gentle boiling.
7. Add 1 to 2 mL of concentrated hydrochloric acid slowly with a Pasteur pipet and then 1 to 2 mL of 30% hydrogen peroxide dropwise with a Pasteur pipet to the stirred, gently boiling solution. Repeat the additions and the boiling until the evolution of brown oxides of nitrogen ceases.
 - Caution must be exercised during the addition of the hydrochloric acid and hydrogen peroxide to avoid spattering of the palladium solution.
 - The vapor from the boiling acid may be checked with water moistened potassium iodide-starch test strips to verify the removal of nitrate from the sample.
 - Hydrogen peroxide generates chlorine gas when added to the hydrochloric acid. Chlorine gas gives a positive test to potassium iodide-starch test strips. Therefore, allow the hydrogen peroxide to decompose, by waiting a minimum of 2 minutes after the initial reaction has subsided prior to testing the evolved gases.
8. Add 30 mL of water and 20 mL of hydrochloric acid to the solution. Swirl to mix.
9. Remove the flask and beaker from the hot plate and allow them to cool to ambient temperature.
10. Tare a one-liter volumetric flask to the nearest 0.01 g and transfer the palladium solution quantitatively with water to the flask.
11. Add 30 mL of concentrated hydrochloric acid to the solution.
12. Dilute with water to a mass that will produce a palladium concentration of exactly 1.000 mg palladium per gram of solution, weighed to the nearest 0.01 g.
 - The final mass of the palladium solution is equal to the mass of the palladium wire multiplied by 1000. For example, if 1.0034 g of palladium wire were dissolved, the final mass of the palladium solution would be 1003.40 g.
13. Mix the solution thoroughly by shaking.
14. Subdivide the palladium standard solution without dilution, into separate 237-mL (or smaller) amber glass bottles and seal with polyethylene lined caps.
 - The stability of the solution in an unopened bottle is not known. The working standard in used deteriorates with time and cannot be used for longer than 4 weeks.

SAMPLE PREPARATION

Obtain a representative sample of fresh or spent catalyst according to UOP Method 918. A total sample must be obtained allowing no loss of sample to dusting.

Spent Catalyst

Carbon Ignition of Whole Pill

Ignition of whole pills, broken pills, fines and dust should be performed according to UOP Method 896.

Grinding and Weighing of Fresh and Spent Catalyst

1. Grind the fresh or spent catalyst sample as described in UOP Method 918.
2. Mix the collected, ground sample thoroughly by randomly shaking it for 5 minutes as described in UOP Method 918.
 - Once the shaking is complete, the homogenous powder must not be agitated again until after the samples are taken.
3. Scoop sample approximately 2 g of the ground fresh or spent catalyst into a weighing scoop.
4. Tare the weighing scoop on the analytical balance to read zero.
5. Transfer the catalyst sample carefully, to avoid dusting, into the bottom of a 400-mL beaker.
 - Catalyst dusting must be avoided to prevent loss of sample.
6. Place the empty weighing scoop onto the analytical balance and record the differential weight to the nearest 0.1 mg.
 - The sample mass will be read as a minus value on the balance.
7. Scoop 2-g portions of fresh or spent catalyst into two tared, pre-ignited ceramic crucibles for determination of the LOI by UOP Method 275, for noble metal containing catalyst.
 - Samples for the LOI must be taken at the same time the sample is weighed for the palladium determination.
 - The two LOI's will be calculated to three significant figures and the results must agree within 5% relative standard deviation or the entire analysis must be repeated.
 - The procedure as outlined in UOP Method 275 must be followed so as to minimize the formation of palladium oxides.

PROCEDURE

All subsequent steps involving handling and heating of concentrated acids or acid solutions must be performed in a fume hood.

Preparation of Standards

1. Transfer 50 mL of catalyst support solution using a graduated cylinder, into each of five 400-mL beakers. Add a borosilicate glass stirring bar to each beaker.

2. Transfer from a weighing buret 4.0-, 6.0-, 7.0- and 8.5-g aliquots (± 0.3 g) of palladium standard, weighed to the nearest 0.1 mg, into 4 of the 400-mL beakers containing the catalyst support solution. Reserve the fifth beaker for the reagent blank to matrix match the samples.
3. Rinse the beaker walls with enough water to raise the volume to approximately 125 mL.
4. Cover the beakers with a ribbed watch glass and stir the solutions.
 - Ribbed watch glasses are suggested because they speed up sample volume reduction.
5. Continue as described in Step 13 under *Sample Dissolution*.

Sample Dissolution

1. Add a borosilicate glass stirring bar to the beakers containing the catalyst sample.
 - The use of borosilicate glass stirring bars is acceptable because they are easy to obtain, but, it is suggested that the quartz stirring bars be used because they are more robust and less likely to break while in use, even though quartz is brittle.
2. Cover each beaker with a ribbed watch glass and add 40 mL of 1:1 sulfuric acid to each beaker through the spout. Swirl to mix.
 - Ribbed watch glasses are suggested because they speed up sample volume reduction.
3. Add 20 mL of phosphoric acid, 10 mL of hydrochloric acid and 5 mL of nitric acid through the spout of each beaker while stirring on a stirring hot plate without heating.
 - Adjust the stirring rate to prevent the sample from spattering.
4. Stop stirring and allow the beaker to stand until the gas evolution subsides.
5. Increase the heat slowly and bring the sample to a boil, while stirring.
 - Adjust the stirring rate to both prevent the sample from bumping, stirring rate too slow; and to prevent the sample from spattering, stirring rate too fast.
6. Continue boiling and stirring until the mixture begins to fume at a hot plate temperature of about 400-500°C.
 - The surface temperature of the hot plate is monitored with a surface thermometer.
 - If a hot plate temperature of 500°C is used instead of 400°C, the time required to dissolve the catalyst is reduced.
7. Continue to fume until the entire sample has dissolved to a crystal clear, colored solution.
8. Swirl the sample to remove any particulate on the beaker walls and continue fuming for 5 minutes.
 - The fuming step is critical to ensure that there is no residual nitric acid in the sample that can interfere with the test.
 - Excessive fuming will cause precipitation of anhydrous aluminum sulfate. If aluminum sulfate precipitates, immediately stop fuming and proceed with the analysis.
9. Remove the samples from the hot plate and allow them to cool to the touch.
 - The hot beakers should not be placed on a cool metal surface because it may cause thermal shock and crack the beaker.

10. Rinse down the beaker walls with a minimum volume of water while stirring and repeat Steps 5 through 7.
11. Remove the samples from the hot plate and allow them to cool to the touch.
12. Stir the solutions and rinse the watch glass and beaker walls with enough water to raise the volume to approximately 125 mL.
13. Add 25 mL of concentrated HCl and 5 mL of 30% hydrogen peroxide to the samples, standards and blank through the beaker spout while covered and continue stirring.
 - The samples, standards and blank are treated identically, beginning at Step 13.
14. After most of the chlorine evolution has subsided, place the beakers on a hot plate and bring to a boil while stirring rapidly.
15. Continue to boil until the volume has been reduced to approximately 100 mL, approximately 30 to 35 minutes.
16. Remove the beakers from the heat and cool to ambient temperature.
17. Transfer the samples, standards and blank quantitatively into separate, tared (± 0.01 g) 500-mL volumetric flasks with water.
18. Fill each flask to approximately 480 mL with water, swirl to mix and allow to cool to ambient temperature.
19. Fill to the mark with water and reweigh. Stopper the flask and mix well.
20. See Table 1 for the proper aliquot of sample, standard or reagent blank to withdraw from each flask.
 - If the palladium content is unknown, use a 50-mL aliquot.
 - If other palladium values than those shown are expected, the aliquot size can be obtained by interpolation.
 - For matrix matching of the samples to the standards, different volumes of reagent blank and samples are combined as indicated in Table 1 to bring the total volume measured to 50 mL.

Table 1
Aliquots for Analysis

Estimated Pd Content, Mass-%	Approximate Sample Aliquot, mL	Reagent Blank, mL
0.3	50	0
0.6	35	15
0.9	18	32
Blank	0	50
Standards	50	0

21. Measure either 50 mL of each standard, or the proper aliquot of sample (Table 1) into a clean, dry 50-mL plastic graduated cylinder.
22. Place the cylinder onto a balance capable of weighing to the nearest 0.001 g and tare the balance to read zero.

23. Pour the solution into a labeled 100-mL volumetric flask (see Note 3). Return the plastic graduated cylinder to the balance and record the differential weight to the nearest 0.001 g.
 - The mass will be read as a minus value on the balance.
24. Transfer 50 mL of reagent blank into the 100-mL volumetric flask for the blank using the plastic graduated cylinder and transfer the volume of reagent blank listed in Table 1 to the sample aliquots in the 100-mL volumetric flasks.
 - The reagent blank volumes need not be weighed.
25. Rinse down the neck of the volumetric flask with water to a volume of no more than 80-85 mL and swirl to mix. Continue as described under ***Spectrophotometric Finish***.

Spectrophotometric Finish

1. Pipet 10-mL of potassium iodide-sodium sulfite solution into each volumetric flask containing the samples, standards and blank. Swirl to mix and stopper.
2. Allow the flasks to stand for one hour.
 - All flasks must be at the same temperature, but the temperature need not be constant.
3. Fill each volumetric flask to the mark with water, weigh if required (see Note 3), stopper and mix well.
4. Calibrate the spectrophotometer once a week at a wavelength of 440 nm using solid, certified standards of known absorbance at that wavelength.
 - Spectrophotometers that utilize internal calibration cannot be calibrated with an external standard.
 - The certified solid standards must be periodically recertified.
5. Adjust the wavelength of the spectrophotometer, if required, using the specific instructions supplied by the manufacturer.
6. Zero the spectrophotometer with water in a 10-mm cell in the sample side and air, without cell, in the reference side (Notes 1 & 2).
7. Measure the absorbance of each solution using a 10-mm cell at a wavelength of approximately 408 nm (Notes 1 & 2).
 - Absorbance of the palladium-iodide complex must be measured at the maximum absorbance. Therefore, the wavelength of the absorbance peak maxima should be determined by scanning the highest palladium concentration standard in the vicinity of 408 nm and selecting the wavelength of the absorbance maximum.
8. Read the absorbance of the blank and each standard or sample solution.
9. Check the spectrophotometer zero to verify that the values are constant within the precision of the instrument.
 - If the zero is not constant (± 0.001 for a 3-place instrument or ± 0.0003 for a 4-place instrument), repeat Steps 6 through 9.
10. Obtain the net absorbances by subtracting the blank from all standards and samples.

CALCULATIONS

Determine the palladium concentration in each standard solution to six decimal places as follows:

$$A = \frac{BCD}{EF} \quad (1)$$

where:

- A** = palladium concentration in standard solution, mg/mL (see Note 3)
- B** = concentration of stock palladium standard solution, mg/g
- C** = mass of stock palladium standard solution weighed out, g
- D** = mass of aliquot of working palladium standard to be color developed, g
- E** = mass of diluted, dissolved palladium working standard, g
- F** = volume of color developed solution, mL (see Note 3)

Calculate the best straight line from the four net absorbances and the corresponding palladium concentrations in the standard solutions, Eq. 1, in mg/mL (see Note 3) by performing a least squares analysis and obtaining the correlation coefficient, *Q*, to 8 decimal places. Use a calculator capable of least squares analysis or the data reduction system on the spectrophotometer, if available.

If the correlation coefficient, *Q*, is less than 0.99986, one suspect standard may be safely discarded and the best straight line recomputed to obtain a correlation coefficient of 0.99986 or larger. In no case can a two point calibration, obtained by using the “best” two of the standards, be used.

Calculate the palladium content of the measured *sample solution*, mg/mL (see Note 3), by using the computation algorithm of the calculator or computer used to compute the best straight line and substituting the net absorbance of palladium for the sample.

Calculate the palladium content of the fresh or spent catalyst sample on a volatile-free basis at 900°C to the nearest 0.001 mass-%, as follows:

$$\text{Pd, mass-\%} = \frac{IKL}{10MN \left(\frac{100_A - P}{100} \right)} \quad (2)$$

where:

- I** = palladium concentration of the color developed sample solution, mg/mL (see Note 3)
- K** = volume of color developed solution, mL (see Note 3)
- L** = mass of dissolved, diluted sample solution, g
- M** = mass of aliquot of dissolved, diluted sample solution, g
- N** = mass of catalyst taken for analysis, g
- P** = loss on ignition of the fresh or spent catalyst at 900°C, mass-%
- 10** = factor to convert from mg/g to mass-%
- 100** = factor to convert mass-% residue after ignition to a decimal fraction
- 100_A** = factor to convert mass-% residue after ignition

NOTES

1. The same cell must be inserted in the same way in the light beam each time a measurement is made using air as a reference. Alternatively, a flow through sample cell, which is never moved from the spectrophotometer, might be used if complete removal of the previous sample is ensured each time spectrophotometric data are measured.

2. If the spectrophotometer does not fulfill *all* of the specifications, then a spectrophotometer capable of accurate and precise measurement of the absorbance to 3-decimal places, i.e., 0.001 Abs, may be used. But, each absorbance *must* be determined a minimum of 9 times. The nine absorbance readings are then averaged to obtain the absorbance that would be equivalent to that read with a 4-decimal place instrument.

3. If desired, the Pd colors can be developed in accurately calibrated volumetric flasks as indicated. Failure to maintain accurately calibrated flasks has been shown to introduce significant errors into the measurements. To avoid the need of certifying volumetric glassware, the color development can also be performed on a mass/mass basis. If the mass/mass alternative is followed, the net masses of the color developed solutions must be measured for all the standards and samples. This requires, weighing the empty 100-mL volumetric flasks and the same flasks after filling to the mark with color developed solutions. The mass of the filled solutions must be taken before stoppering and mixing. Using this alternative, “A” in Eq. 1 and “I” in Eq. 2 will have units of mg/g instead of mg/mL. Similarly, “F” in Eq. 1 and “K” in Eq. 2 will have units of mass in g instead of volume in mL.

PRECISION

Repeatability

Based on two tests performed by each of two analysts on each of two different days (8 tests per lab) and using data collected from laboratories as shown in Table 2, the within-laboratory estimated standard deviations (esd) were calculated at the palladium concentrations shown in Table 2. Two tests performed in one laboratory by different analysts on different days should not differ by more than the allowable difference shown (95% probability).

Reproducibility

The between laboratory estimated standard deviations (esd) were calculated for the palladium concentrations shown in Table 2. Two tests performed in different laboratories by different analysts, on different days, should not differ by more than the allowable difference shown (95% probability).

Table 2

Catalyst	Number of Laboratories	Pd Concentration, mass-%	Repeatability		Reproducibility	
			Within- Lab esd, mass-%	Allowable Difference, mass-%	Between- Lab esd, mass-%	Allowable Difference, mass-%
Fresh	5	0.350	0.0030	0.009	0.0043	0.017
Spent	4	0.321	0.0036	0.010	0.0037	0.017
Spent	1	0.913	0.0018	0.006	- Insufficient Data -	

TIME FOR ANALYSIS

The elapsed time for one analysis is 7 hours. The labor requirement is 6 hours.

REFERENCES

UOP Method 275, "Loss on Ignition of Catalyst at 900°C"

UOP Method 896, "Platinum in Spent Catalyst"

UOP Method 918, "Collection and Grinding of Adsorbents and Catalysts for Analysis"

SUGGESTED SUPPLIERS

Aesar Group/Johnson Matthey, P.O. Box 1087, Seabrook, NH 03874-1087 (508-521-6300)

Baxter Scientific Products, 1430 Waukegan Rd., McGaw Park, IL 60085-6787 (708-689-8410)

Fisher Scientific, 711 Forbes Ave., Pittsburgh, PA 15219 (412-562-8300)

Omega Engineering, Inc., P.O. Box 4047, Stamford, CT 06907 (203-359-1660)

Pyromatics, Inc., P.O. Box 764, 3985 Ben-Hur Ave., Willoughby, OH 44094 (216-951-3985)

National Institute of Standards and Technology, Office of Standard Reference Materials, Gaithersburg, MD 20899 (301-975-6776)

UOP, Process Performance Systems and Equipment, 25 E. Algonquin Rd., Des Plaines, IL 60017-5017 (708-391-2529)

Varian Associates Inc., Varian Instrument Group, 220 Humboldt Ct., Sunnyvale, CA 94089 (408-734-5370)