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Measuring leaf carbon fractions with the ANKOM2000 Fiber Analyzer

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Plant Functional Ecology... | Canadian Airborne Biodi...

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We are still developing and optimizing this protocol.

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Abstract

Here we describe the standardized protocol used by the **Canadian Airborne Biodiversity Observatory** (CABO) to measure carbon fractions in leaf samples, using the **ANKOM2000 Fiber Analyzer**. Prior to the analysis, leaf samples are oven-dried, and then ground with a cyclone mill (2-mm screen). Then, carbon fractions are measured using a sequential digestion procedure to measure neutral detergent fiber (NDF, acid detergent fiber (ADF), acid detergent lignin (ADL). Finally, the residues are ashed in a muffle furnace to determine inorganic recalcitrant materials. This protocol is based on the **manufacturer's protocols**.

Materials

MATERIALS

- Fiber Filter Bags F57 **VWR International (Avantor)** **Catalog #**CA-11022-996
- Neutral detergent solution **VWR International (Avantor)** **Catalog #**CA11023-022
- Acid detergent solution **VWR International (Avantor)** **Catalog #**CA11023-012
- Sulfuric acid **Thermo Fisher Scientific** **Catalog #**A300S-212
- Sodium sulfite **Thermo Fisher Scientific** **Catalog #**S430-500
- Alpha-amylase **VWR International (Avantor)** **Catalog #**CA11023-004

STEP MATERIALS

- Alpha-amylase **VWR International (Avantor)** **Catalog #**CA11023-004
- Sodium sulfite **Thermo Fisher Scientific** **Catalog #**S430-500
- Alpha-amylase **VWR International (Avantor)** **Catalog #**CA11023-004
- Paper pH Strips **Thermo Fisher Scientific** **Catalog #**13-640-508

Protocol materials

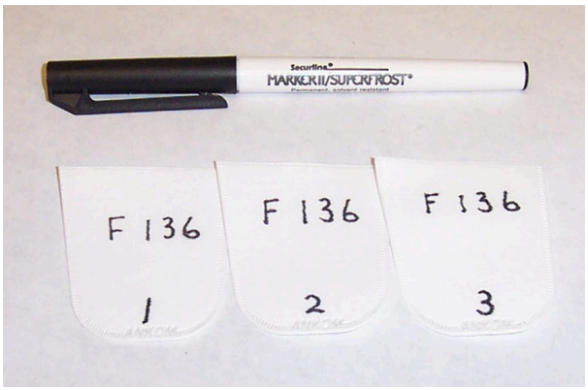
- Sodium sulfite **Thermo Fisher Scientific Catalog #**S430-500
- Alpha-amylase **VWR International (Avantor) Catalog #**CA11023-004
- Paper pH Strips **Thermo Fisher Scientific Catalog #**13-640-508
- Neutral detergent solution **VWR International (Avantor) Catalog #**CA11023-022
- Acid detergent solution **VWR International (Avantor) Catalog #**CA11023-012
- Alpha-amylase **VWR International (Avantor) Catalog #**CA11023-004
- Alpha-amylase **VWR International (Avantor) Catalog #**CA11023-004
- Fiber Filter Bags F57 **VWR International (Avantor) Catalog #**CA-11022-996
- Sulfuric acid **Thermo Fisher Scientific Catalog #**A300S-212
- Sodium sulfite **Thermo Fisher Scientific Catalog #**S430-500
- Sodium sulfite **Thermo Fisher Scientific Catalog #**S430-500
- Alpha-amylase **VWR International (Avantor) Catalog #**CA11023-004
- Paper pH Strips **Thermo Fisher Scientific Catalog #**13-640-508
- Alpha-amylase **VWR International (Avantor) Catalog #**CA11023-004

Before start

Leaf samples need the have been dried for 72 h at 65°C and then ground with a cyclone mill (2-mm screen).

Sample preparation

1 Use a solvent resistant marker to label the filter bags to be used in the analysis.



2 Weigh and record the weight of each empty filter bag to the nearest 0.0001 g (in Fulcrum). Zero the balance.

Note

NOTE: Do not pre-dry filter bags. Any moisture will be accounted for by the blank bag correction.

Equipment

Sartorius Practum	NAME
Analytical balance	TYPE
Sartorius	BRAND
224-1S	SKU
https://www.sartorius.ca/sartoriusCA/en/CAD/home//?setCountry=CA-en	LINK

3 Place 0.45–0.50 g of prepared sample in up to 23 of the bags and record the weight to the nearest 0.0001 g (in Fulcrum) of each. Avoid placing the sample in the upper 4 mm of the bag.

4 Include at least one empty bag in the run to determine the blank bag correction (C1).

Note

NOTE: A running average blank bag correction factor (C1) should be used in the calculation of fiber. The inclusion of at least one blank bag in each run is mainly used as an indicator of particle loss. A C1 larger than 1.0000 indicates that sample particles were lost from filter bags and deposited on the blank bag during the extraction. Any fiber particle loss from the filter bags will generate erroneous results. If particle loss is observed then the grinding method needs to be evaluated.

5 Using a heat sealer, completely seal each filter bag closed within 4 mm of the top to encapsulate the sample.

Note

NOTE: Use sufficient heat to completely seal the filter bags and allow enough cool time (2 s) before removing each bag from the heat sealer.

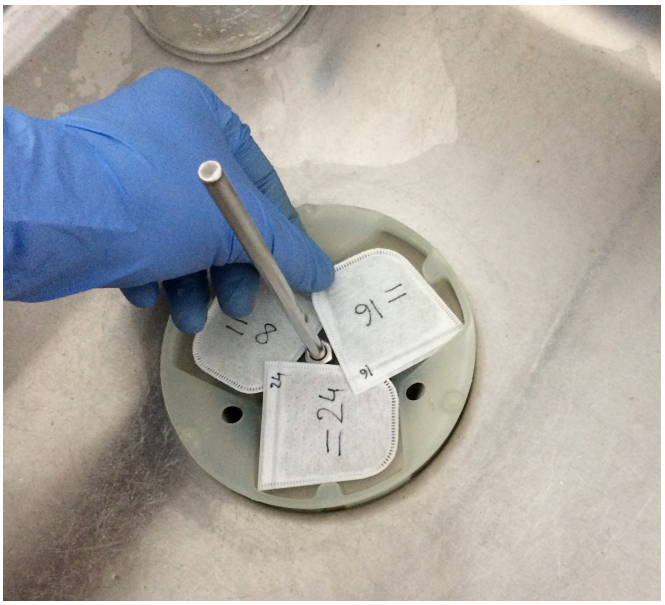
Equipment

Impulse Heat Sealer	NAME
Heat Sealer	TYPE
Uline	BRAND
H-163	SKU
https://www.uline.ca/BL_2253/Tabletop-Poly-Bag-Sealers-Impulse	LINK

6 Spread the sample uniformly inside the filter bags by gently shaking the bags to eliminate clumping.

Neutral Detergent Fiber

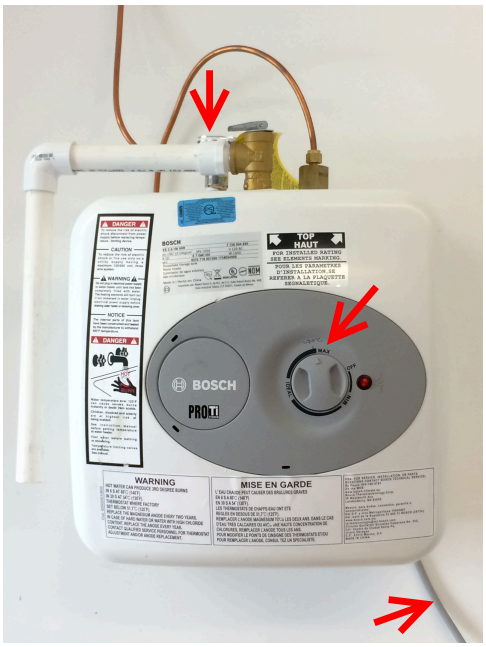
7 Place up to 3 bags on each of eight Bag Suspender Trays (maximum of 24 bags). Stack the trays on the center post of the Bag Suspender with each level rotated 120 degrees in relation to the tray below it. Place the empty 9th tray on top.


1-8
9-16
17-24

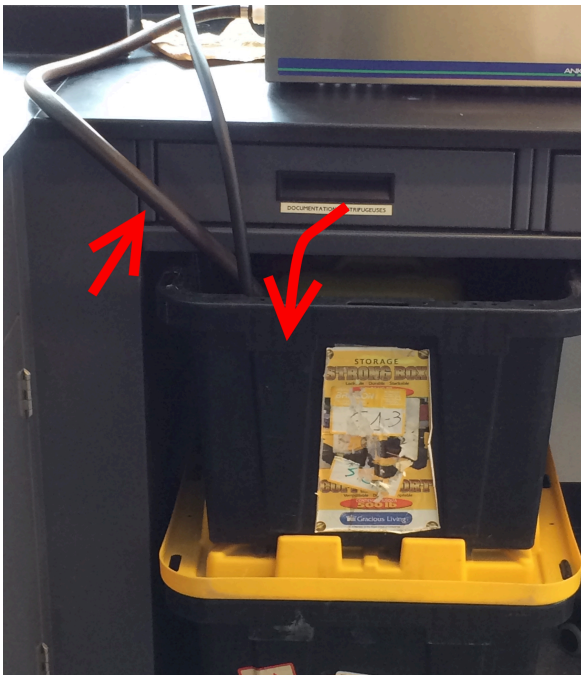
Note

NOTE: All nine trays must be used regardless of the number of bags being processed.

8 Verify that the hot water supply is on (room B-236).



9 Verify that the drain hose is securely positioned in an empty **yellow** waste bin.

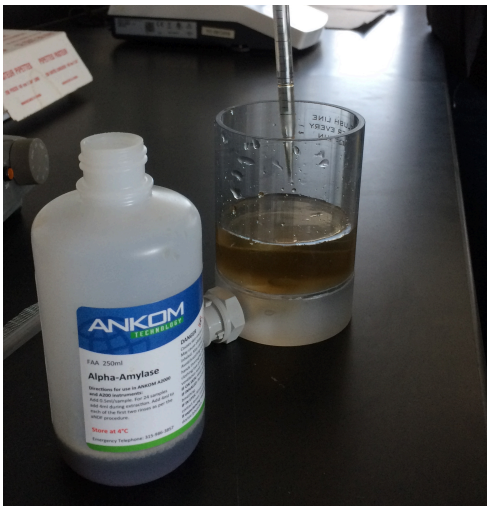


10 Attach the Neutral Detergent (ND) solution hose to the Cubetainer and then to Port A on the instrument.

11 Add 50 ml of tap water in the alpha-amylase dispenser. Add 8.0 mL of alpha-amylase and enough tap water to fill the dispenser (until the line). Attach the Amylase Dispenser Assembly to Port B on the instrument.

Keep the pipette and alpha-amylase bottle next to the instrument for step 16.

Weigh 20 g of Sodium sulfite and keep it for step 16.

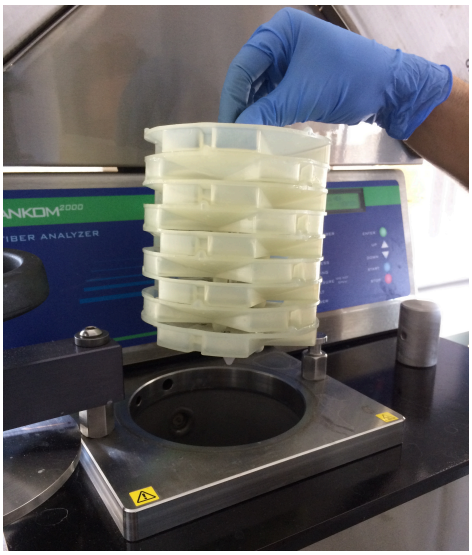


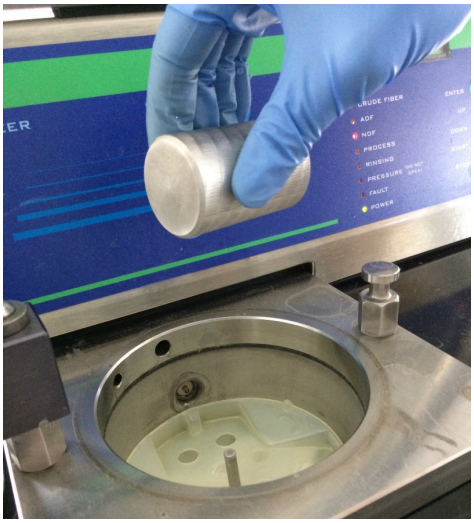
Note

The ANKOM2000 will automatically add the amylase solution to the first and second rinse.

Alpha-amylase **VWR International (Avantor) Catalog #**CA11023-004

12 Open the Vessel Lid and insert the Bag Suspender with bags into the Vessel and place the Bag Suspender weight on top of the empty 9th tray to keep the Bag Suspender submerged.





13 Follow the instructions on the ANKOM2000 display:
Select **NDF**. (Wait to close the Vessel Lid.)

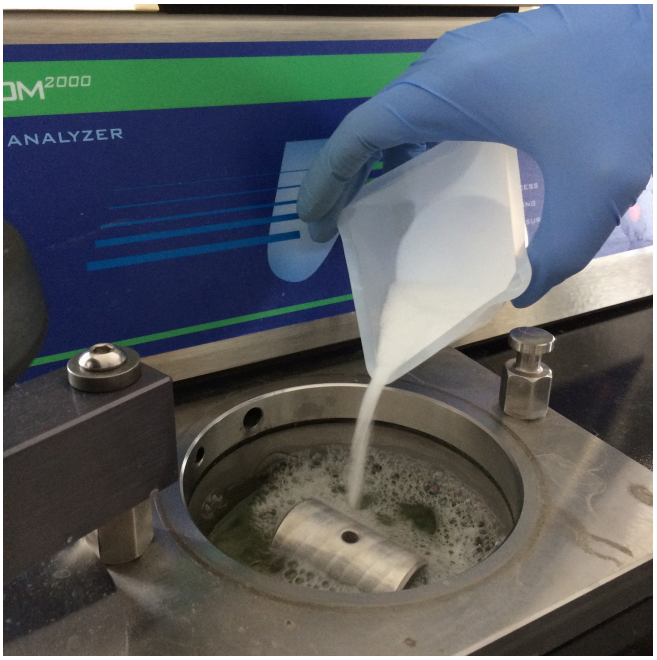
14 The screen will show: Insert samples. Press **Enter**.

15 Confirm hot water is on (>70 °C) and press **START**.

16 After the ND solution has been automatically inserted and agitation begins, manually add 20g of Na_2SO_3 and 4.0 ml of alpha-amylase.

20 g Na2SO3 | 4.0 mL alpha-amylase


ANKOM2000
FIBER ANALYZER


ANALYZER

Sodium sulfite **Thermo Fisher Scientific** **Catalog #**S430-500

Alpha-amylase **VWR International (Avantor)** **Catalog #**CA11023-004

Equipment

Fiber analyzer

NAME

Ankom

BRAND

A2000

SKU

https://www.ankom.com/technical-support/fiber-analyzer-a2000

LINK

17 Close the Vessel Lid.

Equipment

Fiber analyzer

NAME

Ankom

BRAND

A2000

SKU

https://www.ankom.com/technical-support/fiber-analyzer-a2000

LINK

This step takes about 01:30:00 .

18 When the NDF extraction and rinsing procedures are complete, open the Vessel Lid and remove the filter bags. Gently press out excess water from the bags.

Safety information

HOT! Be careful!

Equipment

Fiber analyzer NAME

Ankom BRAND

A2000 SKU

https://www.ankom.com/technical-support/fiber-analyzer-a2000 LINK

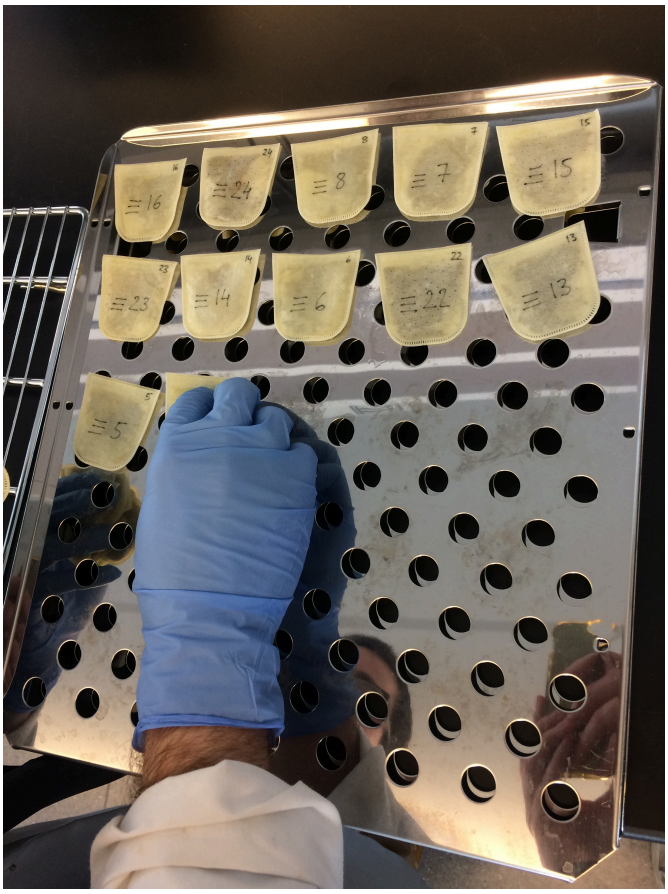
19 Completely dry the filter bags in an oven at 102 ± 2°C for 3 h.

03:00:00

During that time, go to Step 20 and Flush Procedure (Step 21).

Equipment

Oven	NAME
Oven forced-air convection	TYPE
Fisher Isotemp	BRAND
15-103-0510	SKU
http://www.fishersci.ca/shop/products/fisher-scientific-isotemp-general-purpose-heating-drying-ovens/151030510?keyword=true	LINK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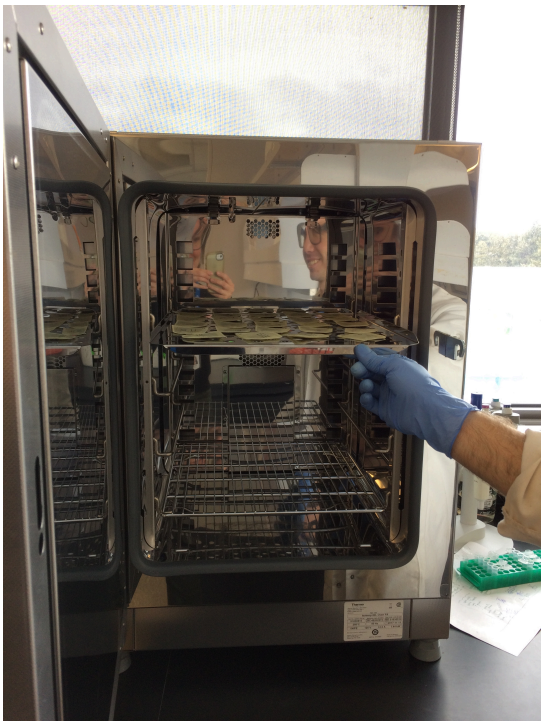


20 During that time, run a flush procedure if necessary.

Detach both cubitainers from ports A and B.

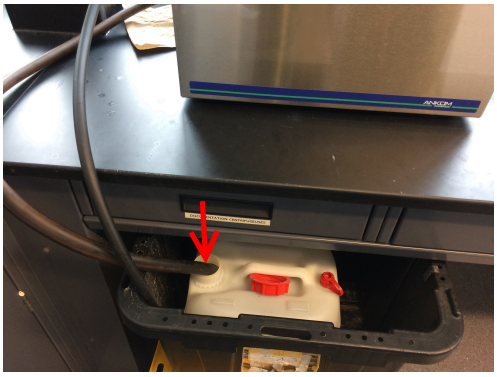
Note

The Flush procedure allows you to clean the system with water. This procedure should be used when changing from one procedure to another (e.g., when preparing to do an ADF analysis after completing an NDF analysis) or when doing an NDF procedure after a previous NDF procedure with more than 2 h between procedures, or before storing the instrument.

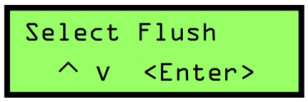
Note

Amylase tends to be sticky. You should always clean the Amylase Dispenser Assembly and flush Port B after every NDF procedure unless the next procedure you are running is another NDF, and you run it within 2 h of the previous procedure.

21 Flush procedure:
Verify that the drain hose is securely inserted into a waste bin.



22 Flush procedure:
Press the arrow keys on the Keypad until you see “Select Flush” on the Display.



23 Flush procedure:
Press **ENTER** on the Keypad.

24 Flush procedure:
Attach the Amylase Dispenser Assembly to port B.

25 Flush procedure:
Fill the dispenser with 100 ml of hot water.

26 Flush procedure:
Attach the Amylase Dispenser Assembly to port A.

27 Flush procedure:
Fill the dispenser with about 100 ml of hot water.

Note

If you press and hold the START key on the Keypad during the Flush operation, water will flow into the Vessel. This will rinse the bottom of the Vessel, but it will not rinse all the way to the top. If you need to rinse anything from the top part of the inside of the Vessel, pour hot water into the Vessel as needed during the Flush operation.

28 When dry, remove the filter bags from the oven and immediately place them directly into a collapsible desiccant pouch and flatten it to remove any air. Cool to ambient temperature for 00:30:00 .

Note

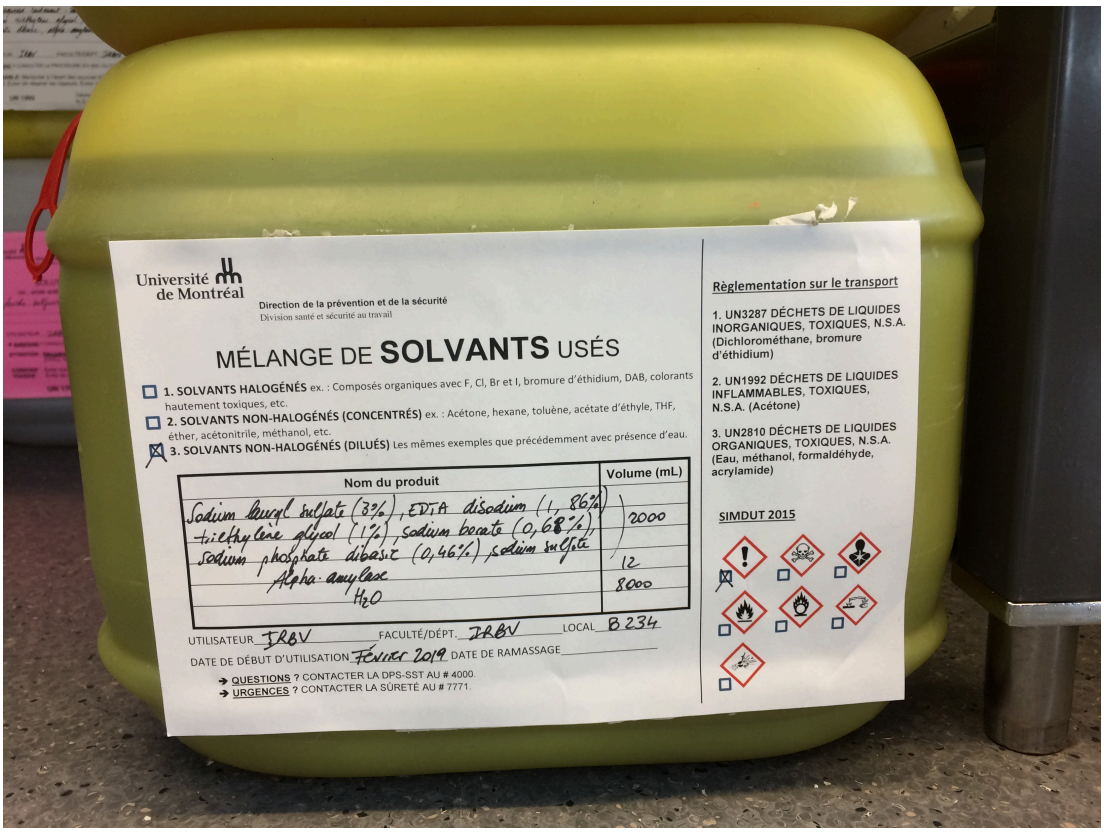
NOTE: Do not use a conventional countertop or cabinet desiccator.

29 Weigh the filter bags to the nearest 0.0001 g and add record the weight (in Fulcrum).

Note

If not processing immediately with the Acid Detergent Fiber (ADF) steps, put the filter bags in the dessicator until the next step.

30 Remove the yellow waste bin and label it properly.



Note

Wait few hours to let the waste cool down before adding the label (it does not stick when it is hot).

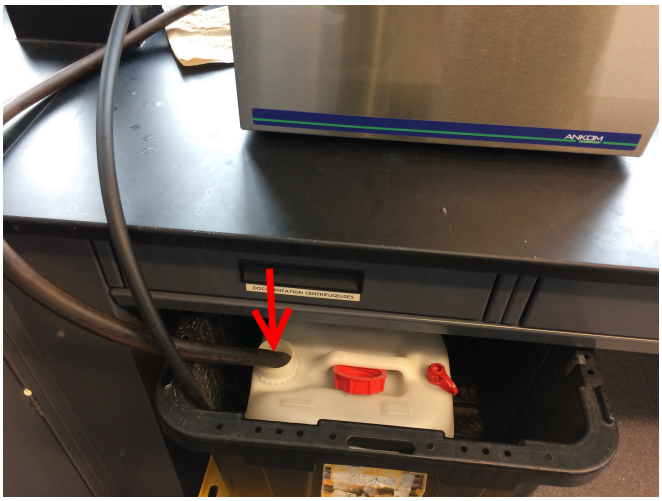
Acid Detergent Fiber

31 Place up to 3 bags on each of eight Bag Suspender Trays (maximum of 24 bags). Stack the trays on the center post of the Bag Suspender with each level rotated 120 degrees in relation to the tray below it. Place the empty 9th tray on top.

Note

NOTE: All nine trays must be used regardless of the number of bags being processed.

32 Insert the drain hose securely into an empty **white** waste bin.



33 Read the Temperature Controller on the right side of the instrument.

Note

If the temperature is higher than 20 °C, cool the Vessel as follows:
a. Fill the Vessel with cold water.
b. When the Temperature Controller reads 20 °C, run the Flush Procedure to drain the water.
c. Repeat steps a and b if necessary.

34 Attach the acid detergent (AD) solution hose to the Cubetainer and then to Port B on the instrument.

35 Open the Vessel Lid and insert the Bag Suspender with bags into the Vessel and place the Bag Suspender Weight on top of the empty 9th tray to keep the Bag Suspender submerged.

36 Follow the instructions on the ANKOM2000 display:
a. Select ADF.
b. Close the Vessel Lid.
c. Confirm hot water is on (>70°C).
d. Press **START**.
01:00:00

37 When the ADF extraction and rinsing procedures are complete, open the Vessel Lid and remove the filter bags. Gently press out excess water from the bags.

Safety information

HOT! Be careful!

38 Completely dry the filter bags in an oven at 102 ± 2°C for 3 h.

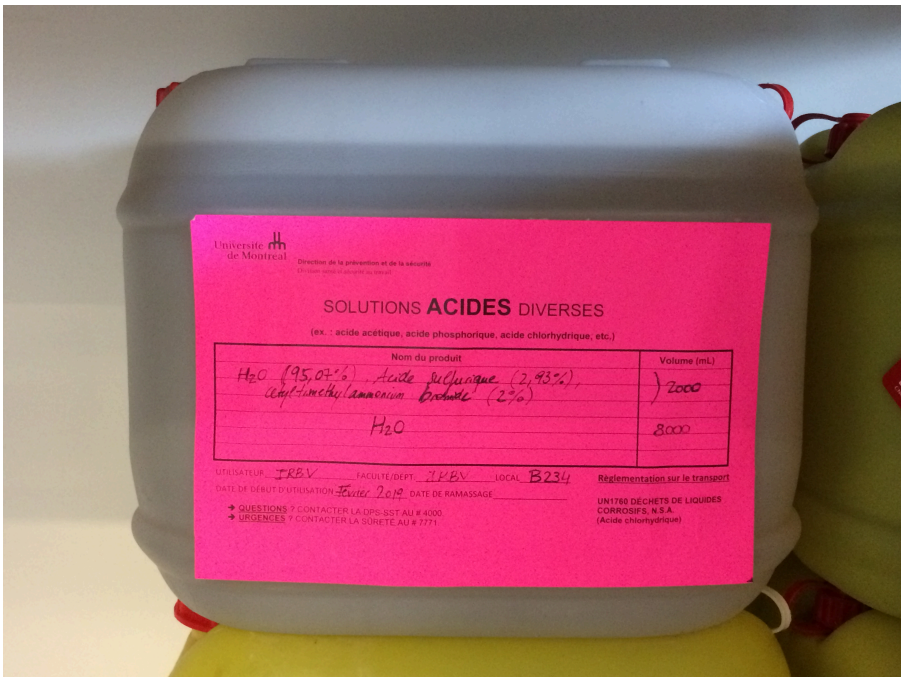
03:00:00

Equipment

Oven

NAME	Oven
TYPE	Oven forced-air convection
BRAND	Fisher Isotemp
SKU	15-103-0510
LINK	http://www.fishersci.ca/shop/products/fisher-scientific-isotemp-general-purpose-heating-drying-ovens/151030510?keyword=true

39 During that time, remove the white waste bin and label it properly.



Note

The label will not stick if the content is hot. Wait a few hours to cool down before sticking the label.

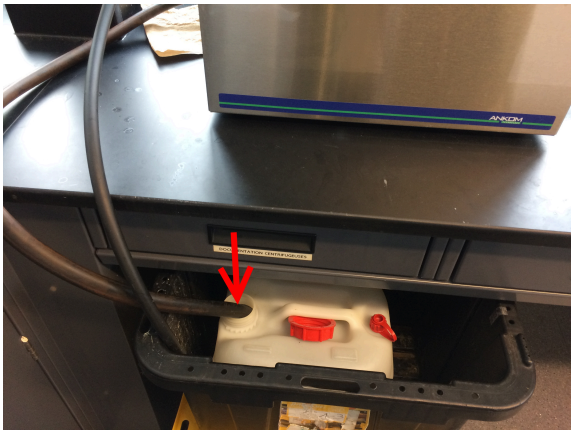
40 During that time, run a flush procedure if necessary.

Detach both cubitainers from ports A and B.

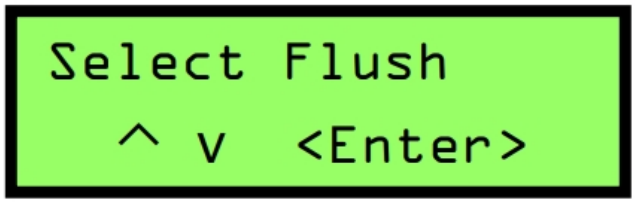
Note

The Flush procedure allows you to clean the system with water. This procedure should be used when changing from one procedure to another (e.g., when preparing to do an ADF analysis after completing an NDF analysis) or when doing an NDF procedure after a previous NDF procedure with more than 2 h between procedures, or before storing the instrument.

41 Flush procedure:
Verify that the drain hose is securely inserted into a waste bin.



42 Flush procedure:
Press the arrow keys on the Keypad until you see “Select Flush” on the Display.



43 Flush procedure:
Press **ENTER** on the Keypad.

44 Flush procedure:
Attach the Amylase Dispenser Assembly to port B.

45 Flush procedure:
Fill the dispenser with 100 ml of hot water.

46 Flush procedure:
Attach the Amylase Dispenser Assembly to port A.

47 Flush procedure:
Fill the dispenser with 100 ml of hot water.

Note

If you press and hold the START key on the Keypad during the Flush operation, water will flow into the Vessel. This will rinse the bottom of the Vessel, but it will not rinse all the way to the top. If you need to rinse anything from the top part of the inside of the Vessel, pour hot water into the Vessel as needed during the Flush operation.

48 Remove the filter bags from the oven, immediately place them into a collapsible desiccant pouch, and flatten it to remove any air. Cool to ambient temperature.

Note

NOTE: Do not use a conventional desiccator container.

49 Weigh the filter bags to the nearest 0.0001 g and record the weight (in Fulcrum).

Equipment

Sartorius Practum	NAME
Analytical balance	TYPE
Sartorius	BRAND
224-1S	SKU
https://www.sartorius.ca/sartoriusCA/en/CAD/home//?setCountry=CA-en	LINK

Note

If not proceeding immediately with the acid lignin method, place the filter bags in the dessicator until the next step.

Lignin method in beakers

50 Prepare a 72% H_2SO_4 solution or take a 250 ml bottle of 72% H2SO4.

Safety information

Danger, highly corrosive.
Exothermic reaction when mixing H_2SO_4 and water. **ALWAYS ADD ACID TO WATER (slowly) AND NOT THE OPPOSITE!**
Wear gloves, labcoat, safety glasses.
Work under the chemical hood.

Note

Under the chemical hood, place a stirring plate, 2 L glass beaker and a magnetic stir bar.
Use a cylinder to measure 242 ml of dH_2O and pour in the beaker.
Start stirring (slow speed).
Use a glass cylinder to measure 758 mL of H_2SO_4 and **SLOWLY** pour into the beaker.
Wait at least 1 h to for the solution to cool down.
In a 1 L glass cylinder, adjust the final volume to 1 L with dH2O.
When completely cooled, aliquot in 250 ml bottles.

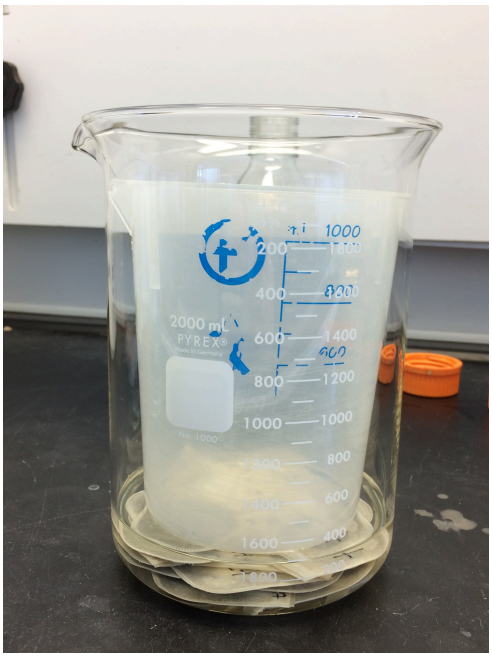
.

51 Place dried filter bags with samples into a 2 L glass beaker and completely cover the bags with 72% H_2SO_4 (approximately 250 ml).

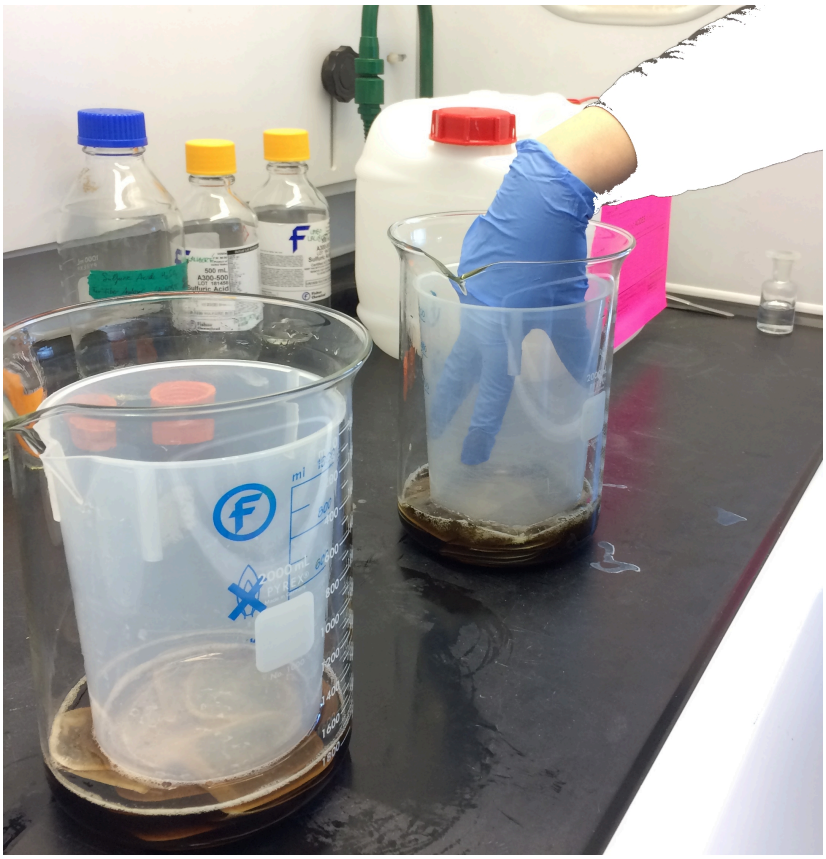
Note

Filter bags **must be completely dry** and at ambient temperature before adding concentrated acid. If moisture (even ambient moisture) is present in the bags, heat generated by the H_2SO_4 and H_2O reaction will adversely affect the results.

52 Place a 1 L beaker inside the 2 L beaker to keep the filter bags submerged.



53 Agitate the bags at the start and at 30-minute intervals by gently pushing and lifting the 1 L beaker up and down approximately 30 times.



54 After 3 h, pour off the H_2SO_4 and rinse with tap water to remove all of the acid.

Note

If acid remains in the filter bags when they go into the drying oven, the samples will burn, leading to erroneous results.

Safety information

H_2SO_4 and rinse water must be poured in a **white** waste bin, with a pink label.

55 Repeat rinses until the pH paper shows neutral color when touching the bags. Handle the bags gently during rinsing. Fine lignin particles can exit the filter bag if not handled carefully.

Paper pH Strips **Thermo Fisher Scientific Catalog #**13-640-508

56 Dry the bags in an oven at 100 °C for 3 h.

03:00:00

Equipment

Oven

NAME	Oven
TYPE	Oven forced-air convection
BRAND	Fisher Isotemp
SKU	15-103-0510
LINK	http://www.fishersci.ca/shop/products/fisher-scientific-isotemp-general-purpose-heating-drying-ovens/151030510?keyword=true

57 Remove the filter bags from the oven and place them directly into a Desiccant/Moisture Stop pouch. Flatten the pouch to remove air. Cool to ambient temperature and weigh the bags to the nearest 0.0001 g. Record the weight (in Fulcrum).

Ashing

58 Rinse 24 crucibles and covers with dH_2O.

59 Dry the crucibles and covers in an oven at 150 °C for 1 h.
01:00:00

Equipment

Oven	NAME
Oven forced-air convection	TYPE
Fisher Isotemp	BRAND
15-103-0510	SKU
http://www.fishersci.ca/shop/products/fisher-scientific-isotemp-general-purpose-heating-drying-ovens/151030510?keyword=true	LINK

60 Cool down crucibles (with lids on) in a metal dessicator for 1h30min.

01:30:00

Equipment

Fisherbrand™ Stainless Steel Desiccator with Stainless Steel Shelves	NAME
Metal Dessicator	TYPE
Fisher	BRAND
S02123	SKU
http://www.fishersci.ca/shop/products/fisherbrand-stainless-steel-desiccator-cabinets-5/s02123#?keyword=desiccator	LINK

61 Weigh empty crucibles, with lids, to the nearest 0.0001 g. Record the weight (in Fulcrum).

Note

Do not wear lab gloves when weighing in this section. Gloves cause static.

Equipment

Sartorius Practum	NAME
Analytical balance	TYPE
Sartorius	BRAND
224-1S	SKU
https://www.sartorius.ca/sartoriusCA/en/CAD/home//?setCountry=CA-en	LINK

62 Fold filters bags into four and insert each bag into its crucible, with the corresponding sample number. Cover with the lid.

63 Put the crucibles (with lids on) in the muffle furnace at 500 °C for 5 h.

05:00:00

Equipment

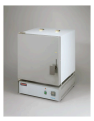
Thermo Scientific™ Thermolyne™ Largest Tabletop Muffle Furnaces	NAME
Muffle furnace	TYPE
Thermolyne	BRAND
10-505-13	SKU
http://www.fishersci.ca/shop/products/thermolyne-largest-tabletop-muffle-furnaces/1050513#?keyword=Thermolyne+Benchtop+Muffle+Furnaces	LINK

64 Change the temperature at 150 °C, O/N.

14:00:00

Equipment

Thermo Scientific™ Thermolyne™ Largest Tabletop Muffle Furnaces	NAME
Muffle furnace	TYPE
Thermolyne	BRAND
10-505-13	SKU
http://www.fishersci.ca/shop/products/thermolyne-largest-tabletop-muffle-furnaces/1050513#?keyword=Thermolyne+Benchtop+Muffle+Furnaces	LINK



65 Turn off the muffle furnace and transfer the crucibles (with lids on) in a metal dessicator for 1h30min.

01:30:00

Equipment

Fisherbrand™ Stainless Steel Desiccator with Stainless Steel Shelves	NAME
Metal Dessicator	TYPE
Fisher	BRAND
S02123	SKU
http://www.fishersci.ca/shop/products/fisherbrand-stainless-steel-desiccator-cabinets-5/s02123#?keyword=desiccator	LINK

66 Weigh crucibles with lids on to the nearest 0.0001 g. Record the weight (in Fulcrum).

Equipment

Sartorius Practum	NAME
Analytical balance	TYPE
Sartorius	BRAND
224-1S	SKU
https://www.sartorius.ca/sartoriusCA/en/CAD/home//?setCountry=CA-en	LINK

67 Wash crucibles and lids with tap water.