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## Standard Practice for Determination of Adsorptive Capacity of Activated Carbon by Aqueous Phase Isotherm Technique<sup>1</sup>

This standard is issued under the fixed designation D3860; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This practice covers the determination of the adsorptive capacity of activated carbon to remove undesirable constituents from water and waste water. It can be used to evaluate the adsorptive capacity of activated or reactivated carbon.

1.2 This practice is not recommended unless special precautions are taken to reduce loss during sample preparation and analysis.

1.3 This practice is recommended to determine the adsorptive capacity of activated carbon for the following applications, but is not limited to these applications:

- 1.3.1 Removal of color from dye mill waste water,
- 1.3.2 Removal of taste or odor constituents, or both, from potable waters,
- 1.3.3 Removal of toxicants from water,
- 1.3.4 Removal of surface-active agents from water,
- 1.3.5 Removal of BOD<sub>5</sub> from sanitary waste waters, and
- 1.3.6 Removal of TOC from industrial waste waters.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

### 2. Referenced Documents

2.1 *ASTM Standards:*<sup>2</sup>

- D1129 Terminology Relating to Water
- D1193 Specification for Reagent Water
- D2652 Terminology Relating to Activated Carbon
- D2867 Test Methods for Moisture in Activated Carbon
- D3370 Practices for Sampling Water from Flowing Process Streams
- E300 Practice for Sampling Industrial Chemicals

### 3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this practice relating to activated carbon, refer to Terminology D2652.

3.1.2 For definition of terms used in this practice relating to water, refer to Terminology D1129.

### 4. Summary of Practice

4.1 This practice consists of the determination of the adsorptive capacity of activated carbon for adsorbable constituents by contacting the aqueous solution with activated carbon, determining the amount of the constituents removed, and calculating the adsorptive capacity from a Freundlich isotherm plot.

4.1.1 Sample weights of activated carbon may have to be adjusted, depending on the concentration of adsorbable constituents in the water.

### 5. Significance and Use

5.1 This practice is used when activated carbon is considered as an adsorbent in treating water. Since both granular and powdered activated carbons are commercially available, a standard practice is needed to ensure that the activated carbons are evaluated under the same test conditions. Specified particle size carbon is to be used to ensure that the same test conditions are used. The practice is generally performed at 20 °C; however, other temperatures may be used and noted.

<sup>1</sup> This practice is under the jurisdiction of ASTM Committee D28 on Activated Carbon and is the direct responsibility of Subcommittee D28.02 on Liquid Phase Evaluation.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.



## 6. Interferences

6.1 The water sample must not contain any immiscible oil.

6.2 Generally, membrane filters contain a slight amount of leachable surfactants and wetting agents that might be a source of detectable error in waters having low concentrations of adsorbable constituents.

## 7. Apparatus

7.1 *Agitator*, able to keep slurried activated carbon in suspension.

NOTE 1—A wrist-action shaker or a magnetic stirrer is suitable as an agitator.

7.2 *Grinding Mill*, capable of grinding material so that 95 % passes through a 325-mesh sieve.

7.3 *Vacuum or Pressure-Filtration Apparatus*.

7.4 *Membrane Filters*, 0.40 to 0.45  $\mu\text{m}$ .

7.5 *Erlenmeyer Flasks*, glass stoppered, 500-mL and 1000-mL capacity.

7.6 *Analytical Balance*, capable of weighing to the nearest 0.1 mg.

7.7 *Oven*, forced-air circulation, capable of temperature regulation between 145 and 155  $^{\circ}\text{C}$ .

7.8 *Constant-Temperature Water Bath*, capable of temperature regulation of  $20 \pm 1$   $^{\circ}\text{C}$ .

7.9 *Pipet*, 100 mL.

## 8. Sampling

8.1 Sample activated carbon that has been sampled according to Practice E300 and reduced in particle size so that 95 % passes through a U.S. 325-mesh sieve by wet screening or equivalent, and oven dried according to Test Methods D2867 (3 h at 150  $^{\circ}\text{C}$  is usually sufficient).

8.2 Collect water samples in accordance with Practices D3370.

## 9. Procedure

9.1 Table 1 is a suggested list of the activated carbon weights and solution sample volumes to be used for the expected concentrations of adsorbable constituents. Suggested carbon weights or solution sample volumes should be adjusted to obtain a maximum of 85 % adsorbate removal and a minimum of 10 % adsorbate removal.

TABLE 1 Solution Sample Volumes and Carbon Weights for Determining Adsorbable Constituents

Concentration of Adsorbable Constituents, mg/L	Solution Sample Volume, mL	Suggested Carbon Weights (Dry Basis)
$\leq 10$	500	1.0, 2.5, 5.0, 7.5, 10.0, 25.0, and 50.0 mg
>10; 100	100	0.01, 0.02, 0.04, 0.10, 0.20, 0.40, 1.0, 2.0, and 4.0 g
>100	100	0.05, 0.1, 0.2, 0.5, 1.0, 2.0, 5.0, and 10.0 g

TABLE 2 Format for Data Reporting

<i>M</i> Grams of Carbon	<i>C</i> Concentration Remaining in Solution, mg/L	( <i>C</i> ) <i>V</i> Constituent Remaining in Solution, mg	<i>X</i> Constituent Adsorbed, mg	<i>X/M</i> = mg/g
Control	500	50	...	...
0.0500	475	47.5	2.5	50
0.1000	450	45.0	5.0	50
0.2000	420	42.0	8.0	40
0.5000	310	31.0	19	38
1.000	200	20.0	30	30
2.000	100	10.0	40	20
5.000	35	3.5	46.5	9.3
10.00	12	1.2	48.8	4.9
20.00	4	0.4	49.6	2.48

9.2 For water containing >10 mg/L adsorbable constituents, pipet aliquots of 100 mL each into 500-mL glass-stoppered Erlenmeyer flasks. For water containing  $\leq 10$  mg/L, measure 500-mL aliquots into 1000-mL glass-stoppered Erlenmeyer flasks.

9.3 Add to the containers the appropriate amount of pulverized activated carbon corrected to dry basis (Table 1) in regular intervals to allow time for filtration. Generally, a 5-min interval is adequate. Use one flask without activated carbon for a control sample.

9.4 After the addition of each activated carbon sample, swirl the flask to wet the carbon. Stopper the flask and place on the agitator. Record the time.

9.5 Allow each flask to shake or agitate for 2 h in a water bath at the desired temperature. Two hours contact time is normally sufficient to achieve steady state. However, a contact time study should be performed to verify that steady state is achieved (see 4.1).

9.6 After 2 h, immediately filter each test and control samples through separate new 0.40 to 0.45- $\mu\text{m}$  membrane filters.

NOTE 2—If the water sample contains volatile constituents, use pressure filtration with nitrogen gas to reduce loss.

NOTE 3—It is recommended that each membrane filter be rinsed with 500 mL of reagent grade Type II water (Specification D1193) prior to filtration.

9.7 Immediately analyze the filtrates for the specific constituent of interest and record the results along with the corresponding carbon weight.

## 10. Calculation

10.1 Determine the amount of constituent adsorbed, *X*, as follows:

$$X = C_o V - CV$$

where:

*X* = amount of constituent adsorbed, mg,

*C<sub>o</sub>* = concentration of constituents before carbon treatment, mg/L,

*C* = concentration of constituents after carbon treatment, mg/L, and

*V* = volume of sample, *L*.



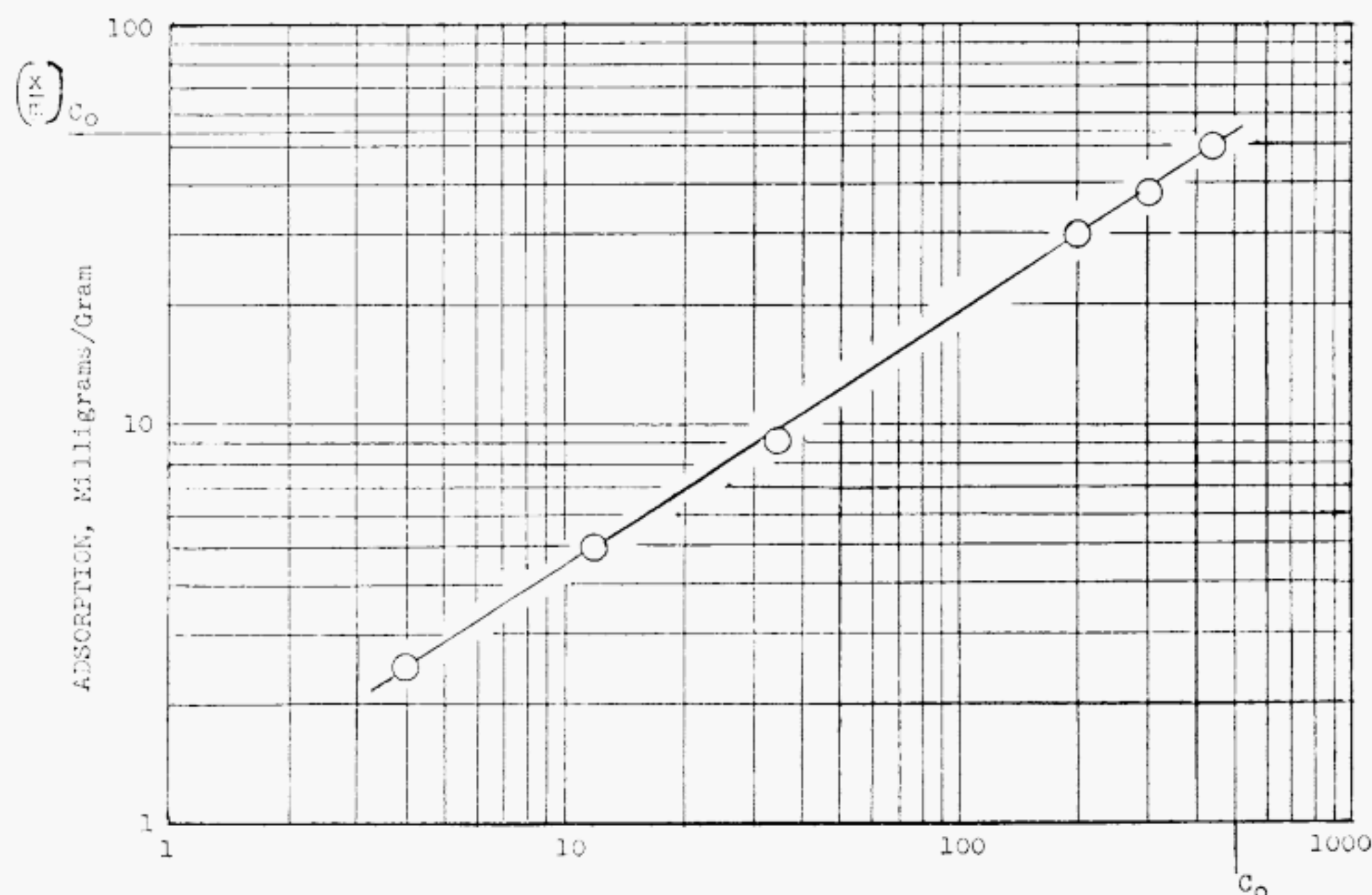


FIG. 1 Plotting of Data Concentration (C) mg/L

10.2 Determine the amount of constituent adsorbed per unit weight of carbon,  $X/M$ , as follows:

$$X/M = \frac{(C_o V - CV)}{M}$$

where:

- $M$  = weight of carbon, g,
- $X$  = amount of constituent absorbed, mg,
- $X/M$  = constituent absorbed per unit weight of carbon, mg/g,
- $C_o$  = concentration of constituents before carbon treatment, mg/L,
- $C$  = concentration of constituents after carbon treatment, mg/L, and
- $V$  = volume of sample, L.

## 11. Report

11.1 See Table 2 for the recommended format for data reporting.

### 11.2 Plotting of Data:

11.2.1 Use three-cycle log/log paper and plot concentration remaining in mg/L on the abscissa and  $X/M$  on the ordinate, and then connect the points. See Fig. 1.

11.2.2 If a vertical line is erected from the point on the abscissa corresponding to the original concentration  $C_o$  and the isotherm plot is extrapolated to intersect this line, the  $X/M$  value at the point of intersection can be read from the ordinate. This value termed  $[X/M] C_o$  represents the amount of impurity adsorbed when the carbon is in equilibrium with the influent concentration. This value represents the ultimate capacity of the carbon for the adsorbate.

## 12. Precision and Bias

12.1 *Precision*—The precision is limited by the precision of the test methods used in determining the concentrations of the constituents.

12.2 *Bias*—The bias is limited by the bias of the test methods used in determining the concentrations of the constituents.

## 13. Keywords

13.1 activated carbon

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