Designation: D7708 – 23a

Standard Test Method for Microscopical Determination of the Reflectance of Vitrinite Dispersed in Sedimentary Rocks[1]

This standard is issued under the fixed designation D7708; 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 (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the microscopical determination of the reflectance measured in immersion oil of polished surfaces of vitrinite dispersed in sedimentary rocks. This test method can also be used to determine the reflectance of macerals other than vitrinite dispersed in sedimentary rocks.

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

1.3 *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.*

1.4 *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:*[2]

D121 Terminology of Coal and Coke
D388 Classification of Coals by Rank
D2797 Practice for Preparing Coal Samples for Microscopical Analysis by Reflected Light
D2798 Test Method for Microscopical Determination of the Vitrinite Reflectance of Coal
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions*—For definitions of terms, refer to Terminology D121.

3.2 *Abbreviations:*

3.2.1 $R_o ran$—mean random reflectance measured in oil using a fixed microscope stage. Other organizations may use other abbreviations for mean random reflectance.

3.2.2 $R_o max$—mean apparent maximum reflectance measured in oil using a fixed microscope stage and a rotating polarizer in the incident light path. Other organizations may use other abbreviations for mean apparent maximum reflectance.

3.3 *Definitions of Terms Specific to This Standard:*

3.3.1 *alginite, n*—a primary liptinite maceral occurring in structured morphologies, telalginite, and unstructured morphologies, lamalginite.

3.3.2 *bituminite, n*—an amorphous primary liptinite maceral with low reflectance, occasionally characterized by colored internal reflections in reflected white light and weak orange- to brown fluorescence, derived from bacterial biomass and the bacterial decomposition of algal material and faunal plankton (**1**). Bituminite is equivalent to the amorphous organic matter recognized in strew slides of concentrated kerogen (**2**). [3]

3.3.2.1 *Discussion*—Bituminite may be distinguished from vitrinite by lower reflectance, as well as higher fluorescence intensity if fluorescence is present in vitrinite. Bituminite has poorly-defined wispy boundaries and may be speckled or unevenly colored from dark brown, dark gray, to almost black in reflected white light, whereas vitrinite has distinct boundaries and is blockier and evenly colored. The occurrence of bituminite in association with lamalginite and micrinite is common. Bituminite may be expected to occur in lacustrine or marine settings. It is less commonly present in fluvial or similar proximal depositional environments, where vitrinite may be expected to occur in greater abundance.

[1] This test method is under the jurisdiction of ASTM Committee D05 on Coal and Coke and is the direct responsibility of Subcommittee D05.28 on Petrographic Analysis of Coal and Coke.

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

[3] The boldface numbers in parentheses refer to a list of references at the end of this standard.

3.3.3 *chitinozoan, n*—a group of flask-shaped, sometimes ornamented marine microfossils of presumed metazoan origin which are composed of 'pseudochitin' proteinic material and which occur individually or in chains. Chitinozoan cell walls are thin, opaque to translucent, and range from dark gray to white in reflected white light similar to vitrinite. Chitinozoans are common in Ordovician to Devonian marine shales.

3.3.4 *conodont, n*—the phosphatic, tooth-like remains of marine vertebrate worm-like animals present from the Cambrian through Triassic, composed predominantly of apatite with subordinate amounts of organic matter. Conodont morphology is variable, but often well-defined denticles and blades are preserved. In reflected white light examination conodonts range from pale yellow to light brown to dark brown and to black.

3.3.5 *fusinite, n*—an inertinite maceral distinguished principally by the preservation of some feature(s) of the plant cell wall structure, high relief, and reflectance substantially higher than first cycle vitrinite in the same sample. When less than 50-µm in size this maceral is assigned to inertodetrinite. Other organizations may define macerals using different technical specifications.

3.3.6 *graptolite, n*—colonial, chitinous animal which occurs as thin, elongate bodies sometimes showing complex skeletal morphology and with reflective dark gray to white color in reflected white light similar to vitrinite (**3**). Graptolites occur from the Cambrian through Carboniferous.

3.3.7 *huminite, n*—maceral group present in lignite, some subbituminous coal, and thermally immature sedimentary rocks with reflectances intermediate to those of associated darker liptinites and brighter inertinites in reflected white light (**4**). The huminite maceral group is equivalent to the vitrinite maceral group that occurs in some subbituminous and higher rank coals with measured reflectance values greater than 0.5 % $R_o ran$(**5**).

3.3.8 *inertinite, n*—maceral group with macerals that exhibit higher reflectance than other organic components in the same sample: for example, semifusinite, fusinite, and inertodetrinite. Inertinite macerals generally lack fluorescence and usually retain preserved plant cell wall structure (**6**). Individual macerals of the inertinite group generally are not distinguished in practice when dispersed in sedimentary rocks (**7**).

3.3.9 *inertodetrinite, n*—an inertinite maceral occurring as individual, angular, clastic fragments incorporated within the matrix of other macerals (commonly vitrinite) or minerals, and in the size range from 2 µm to 50 µm. Other organizations may define macerals using different technical specifications.

3.3.9.1 *Discussion*—Inertodetrinite is derived through the disintegration of other inertinite macerals, that is, fusinite and semifusinite, by mechanical abrasion during transport.

3.3.10 *kerogen, n*—fraction of dispersed or concentrated organic matter, or both, occurring in sediments and sedimentary rocks that is insoluble in non-polar organic solvents.

3.3.11 *lamalginite, n*—an unstructured liptinite maceral with low reflectance distinguished primarily by the presence of fluorescence and lamellar character.

3.3.12 *liptinite, n*—maceral group with macerals that exhibit lower reflectance than other organic components in the same sample of sedimentary rocks and coal, appearing black to dark gray in reflected white light and that fluoresce under blue to ultraviolet light in coals ranked medium volatile bituminous and lower. Liptinite maceral fluorescence can be used as a qualitative thermal maturity indicator as fluorescence changes from green to yellow to orange before becoming extinguished at advanced thermal maturity.

3.3.12.1 *Discussion*—Liptinite macerals are observed only in coals of coal rank or degree of coalification up to approximately the high volatile bituminous to medium volatile bituminous transition, and in sedimentary rocks of equivalent thermal maturity up to the late stages of oil generation and early stages of gas generation. Liptinite macerals undergo chemical changes during maturation which render their optical distinction from vitrinite and inertinite macerals difficult at rank higher than medium volatile bituminous.

3.3.13 *maceral, n*—an organic component occurring in sedimentary rocks that is distinguished on the basis of its optical microscopic properties, primarily reflectance and morphology.

3.3.14 *maceral classification, n*—the systematic division of the organic components (macerals) in sedimentary rocks and coal based on their appearance in the optical microscope under reflected white light and epi-fluorescence.

3.3.15 *micrinite, n*—an inertinite maceral, generally nonangular, exhibiting no relict plant cell wall structure, smaller than 10 µm and most commonly occurring as granular particles around 1 µm to 5 µm diameter. Other organizations may define macerals using different technical specifications.

3.3.15.1 *Discussion*—Micrinite is a secondary maceral formed from liptinite macerals during maturation. Other origins may be possible, including bacterial degradation of liptinite macerals, or diffuse scattering of reflected light from inorganic constituents.

3.3.16 *mineral matter, n*—in sedimentary rocks, the nonorganic fraction composed of physically discrete particles of minerals such as clays, pyrite, quartz, carbonates, etc., and all elements other than carbon, hydrogen, oxygen, nitrogen and sulfur in the organic fraction.

3.3.17 *recycled vitrinite, n*—vitrinite that has undergone at least one additional cycle of burial, exhumation, and erosion in contrast to first cycle vitrinite which has undergone only one burial cycle. The additional cycle may result in exposure to thermal maturation, chemical or thermal oxidative processes, or both, and mechanical abrasion (sometimes resulting in increased particle rounding) that is not experienced by first cycle vitrinite contained in the same sample.

3.3.17.1 *Discussion*—Recycled vitrinite has higher reflectance than co-occurring first cycle vitrinite, and sometimes is less angular, due to the rounding of grain boundaries experienced during transportation. Recycled vitrinite may have bright or dark halos, representing thermal oxidation and weathering processes, respectively, which are not present in the co-occurring first cycle vitrinite. Recycled vitrinite has a higher variance of reflectance values, representative of the many possible sources and processes occurring during transportation,