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Letter
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TERMINOLOGY AND SYMBOLS FOR USE IN ULTRAVIOLET, VISIBLE, AND INFRARED ABSORPTOMETRY

I. INTRODUCTION.

Various members of the staff of the National Bureau of Standards have for some time felt the need of adopting a more unified system of terms and symbols for use in Bureau publications dealing with spectral transmission or absorption measurements. Despite efforts and proposals made by various groups or individuals in the fields of optics and chemistry no such system is available that is considered wholly satisfactory and acceptable for such a purpose.

To fill this need, those in the Bureau most concerned with the matter have formulated the terminology given below and have agreed to use it in papers published in the Journal of Research NBS, in the forthcoming NBS Handbook of Physical Measurements, and in various other NBS publications. Those taking part in this formulation are members of the following sections of the Bureau: In the Optics Division, the Sections of Spectroscopy, Polarimetry, Photometry and Colorimetry, Optical Instruments, and Radiometry; in the Chemistry Division, the Sections of Analytical Chemistry and Standard Samples, Gas Chemistry, Physical Chemistry and pH Standards, Thermochemistry and Hydrocarbons, and Uranium and Related Products; and in the Organic and Fibrous Materials Division, The Textile Section.

This letter circular has been prepared to answer inquiries on the subject, for it is known that many are interested. However, there is no desire to urge the acceptance of these terms and symbols by any other group. Many of those participating are members of committees engaged in similar work in other organizations, such as the Optical Society of America, and the American Society for Testing Materials, and in such capacity have recommended or adopted terms or symbols at variance with those given below. Furthermore, in publications appearing in the journals of those and other technical organizations, the various individuals are free to use whatever system of terms and symbols is most suitable for the occasion.

While no terminology was available that was wholly acceptable for the purpose, in view of the widely varying interests of those in the group, it was nevertheless desirable to use those terms and symbols that were well established, provided they were acceptable to the majority. This has been done so far as possible and many of the definitions, names and symbols given are consistent with those used by other groups.

One other point may be noted. The present set of terms and symbols has been made brief and simple, consistent with the need. Many other terms would be defined and many additional symbols would be necessary if it were desired to cover all possible phases of the subject. By limiting the terminology to that given, it was possible to avoid an excess of relatively useless terms and the use of Greek (except where well established), bold-face, script, or other special symbols.

II. GENERAL CONSIDERATIONS

In addition to the specific definitions given in sections III and IV, agreement was also reached with respect to the following:

1. Endings of Words

The ending -tion (occasionally "-sion") is reserved for designation of processes. Thus we have "radiation," "absorption," "reflection," "transmission." Conformity to this usage eliminates such words for specific terms, but does not eliminate their use as adjectives, such as "absorption band," "transmission terms," etc.

Terms ending in -ance, -ancy refer to passive properties of objects, whereas those ending in -ity refer to properties of materials. The word index also refers to properties of materials.

2. Radiant Energy

Radiant energy is energy traveling through space in the form of electromagnetic waves of various wavelengths. It is the entity that is emitted from radiators and that is reflected, refracted, absorbed, or transmitted by various objects and materials. (Consistent with this definition it is appropriate to refer to "ultraviolet energy" or "infrared energy," but incorrect to refer to ultraviolet or infrared "radiations").

3. Light

Light is the aspect of radiant energy of which a human observer is aware through the visual sensations arising from stimulation of the retina of the eye. Quantitatively light is radiant energy evaluated in terms of the standard luminosity function. (Usually radiant energy must have wavelengths between approximately 380 and 770 mμ if it is to have a luminous aspect. But it is not proper to state that radiant energy of wavelengths 380 to 770 mμ is synonymous with light. The expressions "ultraviolet light" and "infrared light" are not to be used.)

The term light is not used elsewhere in this letter circular.

4. Wavelength and Frequency.

The symbol for the wavelength of radiant energy is λ . The units in which wavelengths are expressed should be restricted to those conventionally used for each spectral range; i.e., millimicrons (mμ) or angstroms (A) for the ultraviolet and visible and microns (μ) for the infrared.

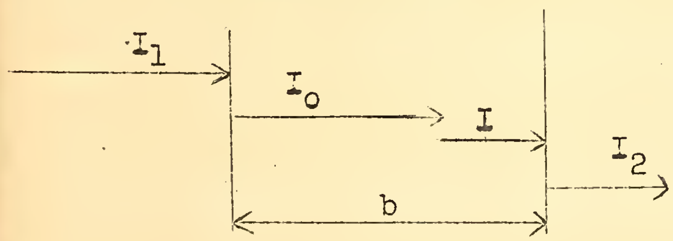
The symbol for frequency is ν . In place of frequency a quantity designated as wave number is widely used, defined as $1/\lambda_{vac}$ (the unit of λ in this usage is usually the centimeter).

The relation between wavelength and frequency is

$$\nu = v/\lambda$$

where v is the velocity of light. It may perhaps be emphasized that both v and λ change whenever radiant energy of frequency ν passes from a medium of one refractive index to a medium of different index. The frequency itself does not change, however, and is thus more fundamental than wavelength for theoretical studies.

III. TERMS RELATING TO THE RECTILINEAR TRANSMISSION OF HOMOGENEOUS RADIANT ENERGY (RADIANT ENERGY OF A "SINGLE" FREQUENCY) THROUGH A HOMOGENEOUS, ISOTROPIC, NONMETALLIC MEDIUM HAVING PLANE, SMOOTH, PARALLEL SURFACES.



(This diagram is, of course, schematic. Since only ratios of radiant energy are considered in these derivations, any more fundamental consideration of the spatial variants of radiant energy, such as radiant intensity, radiant flux, and areal density of radiant flux, seems unnecessary.)

1. Let I_1 represent the radiant energy incident upon the first surface of the sample, I_0 that entering the sample, I that incident upon the second surface, I_2 that leaving the sample.

2. $T = I_2/I_1$ = <u>transmittance</u> of the sample. (100 T = percentage transmittance.)

3. $T_i = I/I_o$ = <u>internal transmittance</u> of the sample.

4. $A_i = -\log_{10}T_i = \log_{10}1/T_i = \log_{10}I_o/I$ = <u>absorbance</u> of the sample.

5. Let b represent the length of absorbing path in the sample.

6. $a_i = A_i/b$ = <u>absorbance index</u> of the material.

7. Other quantities derived from the above are occasionally used. These are $T_i^{1/b}$ which has been called <u>transmissivity</u>, $1 - T_i^{1/b}$ which has been called <u>absorptivity</u>, and $1 - T_i$, which has been called <u>absorptance</u>. No symbols are suggested for these terms. If it is desired to use these quantities it is suggested that the above expressions be used rather than other symbols.

8. In the above, the thickness, b, or the unit of thickness, should always be given. The temperature of the sample during the measurements should also be stated when this is a matter of importance.

IV. TERMS RELATING TO THE RECTILINEAR TRANSMISSION OF HOMOGENEOUS RADIANT ENERGY, THROUGH A HOMOGENEOUS, ISOTROPIC, NONMETALLIC MEDIUM SUCH AS A LIQUID, MIXTURE, SOLUTION, VAPOR, OR GAS CONFINED BETWEEN THE WINDOWS OF A CELL.

1. Let T_{soln} represent the (over-all) transmittance of a given cell containing a solution or homogeneous mixture of solids, liquids, vapors, or gases, of which the compound of interest is the solute or one constituent.

2. Let T_{solv} represent the (over-all) transmittance of the same or a duplicate cell containing pure solvent, or the same mixture in the same relative proportions minus the constituent of interest.

3. $T_s = T_{soln}/T_{solv}$ = <u>transmittancy</u> of the sample. (100 T_s = percentage transmittancy.) (T_s does not precisely equal $(T_i)_{soln}/(T_i)_{solv}$. However, with end plates of refractive index not greater than 1.5, the error is negligible for most purposes).

4. $A_s = -\log_{10}T_s = \log_{10}1/T_s$ = <u>absorbancy</u> of the sample.

5. Let b represent the length of absorbing path between the boundary layers of the solution, and c the concentration of the solute or constituent of interest.

6. $a_s = A_s/bc$ = absorbancy index of the material.

7. a_M = molar absorbancy index, c being expressed in moles per liter and b in centimeters, and the temperature being given.

8. a_x = partial absorbancy index, where x refers to the component in question.

9. In the above, the thickness and concentration, or the units, should always be given. The temperature of the sample during the measurements should also be given when this is a matter of importance.