Asian Journal of Chemistry Vol. 11, No. 4 (1999), 1556–1558

NOTE

Spectrophotometric Determination of Suspending Solid in Natural Water

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Several absorption equations for suspension liquid have been established. The primary relationship of the absorbance (A) with wavelength (λ) and characteristic factors φ and ε of the suspending solid is the first to be expressed as $A = \phi\varepsilon^{-2}\lambda^{-\sqrt{\varepsilon}}$ |. The spectrophotometric determination of suspending solid conccentration in liquid is given out, which is much more simpler than than the conventional one.

The size of solute particle in ordinary solutions is generally between 0.1 and 1 nm. Systems which consist of media with dissolved or dispersed particles ranging approximately from 1 nm up to several hundreds nm in size are called colloids. There are many systems, however, where the particles are considerably larger and may in fact range from the upper limit for colloid up to 100 μm in size, are named suspension liquids which is a typical multi-phase system. It is shaped with the solid particle to disperse into water or other medium. A suspension liquid is often relatively stable though the suspending particle is always under slow sedimentation. The particle diameter is often more than the visible light wavelength between 400 and 800 nm. Therefore, if the visible light passes through a suspending liquid, the suspending solid will reflect or absorb the light. suspending solid is one of the essential pollutants in environment monitoring. It is always determined by gravimetry[1], which is poor of precision and accuracy as well as time consuming. Only a few papers were reported[2–6] concerning the determination and property of suspending solid, but also most of them described how to improve the gravimetric determination of suspending solid. Some of cations and anions[7–9] were often changed into the infusible suspending solids so as to be determined by gravimetry though such an accuracy is poor.

Development of Principle

At first, two suppositions on the suspending particle are suggested as follows: (1) the suspending particles are all spherical. (2) None of the dissolution, flocculation and chemical reaction will happen. The absorption spectrum (curve a) of a suspension liquid is different from that (curve b) of a colour solution from Fig. 1. Curve b has always a peak but curve a not. Because the suspending

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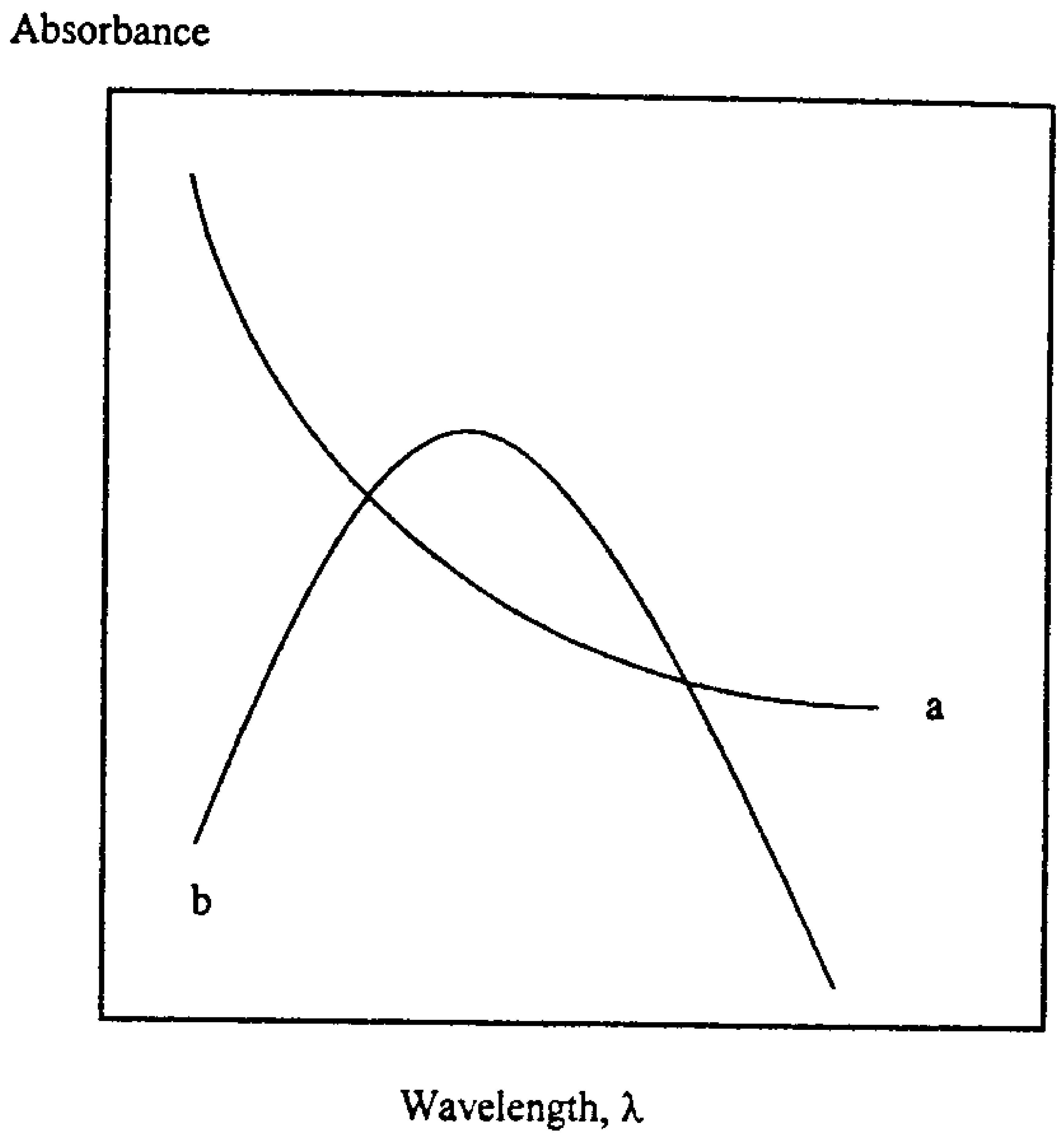

Fig. 1. Absorption spectra: (a) suspension liquid, (b) color solution

particles use their bodies to resist the light, the absorbance (A) should be directly proportional to the particle's amount and sectional area. The shorter the light wavelength or the larger the suspending particle's sectional area, the higher the absorbance should be. Therefore we can write initially the expression as following: $A = \phi\varepsilon^{-2}f(\lambda, \phi, \varepsilon)$ where $\phi = k_1n$ and $\varepsilon = k_2/(k_3d)$. All k_1, k_2 and k_3 are ratio coefficients, n is particle amount, d the average diameter and λ the light wavelength (unit h nm, that is 100 nm). Lots of experiments were made in the laboratory. The further expression is obtained as followed:

$$A = \phi\varepsilon^{-2}\lambda^{-\sqrt{\varepsilon}} \qquad (1)$$

From this expression, we calculate the volume and mass concentration (V_{SS} and C_{SS}) of the suspended solid in liquid. Because $V_{SS} = k_5nd^3$ (μL/L) and $C_{SS} = k_5nd^3 . \rho$ (mg/L) where k_5 is a constant and ρ is density of the suspended particle in kg/L. The following formulas are expressed:

$$V_{SS} = k\phi\varepsilon^{-3} \qquad (2)$$

and

$$C_{SS} = k\rho\varphi\varepsilon^{-3} \qquad (3)$$

where k is a constant.

In order to obtain both k and k′ in equations above a stable suspension liquid should be chosen and made. We know silver chloride has very little dissociation constant ($k_{sp} = 1.56 \times 10^{-10}$ at 25°C). The reaction, $Ag^+ + Cl^- \rightarrow AgCl$ was selected as standard reference to produce stable AgCl suspension liquid. Such a reaction is complete and selective in the presence of a lot of Cl^-. Of course, AgCl, 0.100 mmol/L (14.35 mg/L) should be formed by 0.100 mmol/Ll Ag^+ with exceeded Cl^- at pH 1. The measurement results for this suspension liquid in a spectrophotometer with 1 cm cell showed that the average ε is equal to 50 and ϕ to 12500. The average $\varphi\varepsilon^{-3} = 0.1$. As a result k = 144. Because of both the stable liquid and the expansion of updated AgCl particles, the specific density (ρ) of such suspending particles was regarded as 1.00 $kg/(dm)^3$ that was near to that water. The final equations are expressed as follows:

$$C_{ss} = 144\varphi\varepsilon^{-3} \quad (4)$$

The further experiments showed that ε of the suspension liquid is often between 0.1 and 100. Because ε is in invese ratio to the particle diameter (d) different ε is corresponded with the different average particle diameter. The recommended results were listed in Table 1. While ε is more than 10 the suspension liquid will become colloid solution. If ε is less than 0.1, the visible settlement may be observed and the suspending particles become too big to remain stable absorption.

TABLE-1
RECOMMENDED PARTICLE DIAMETER RANGE FROM ε

Determined factor, ε	The recommendation of average particle diameter, d (m)
less than 0.1	more than 10^{-4}
between 0.1–1	between 10^{-4}–10^{-5}
between 1–10	between 10^{-5}–10^{-6}
more than 10	less than 10^{-6}

From equation (4) it is very easy and simple for the concentration of some components to be determined by preparing a suspension liquid, for example, Cl^- (with Ag^+), SO_4^{2-} (with Ba^{2+}), S^{2-} (with Zn^{2+}) and suspended solid in environmental water. Therefore, the accurate determination of cations and anions can be realized using such a dual-wavelength spectrophotometry by forming the infusible compounds. It will play an important role in the invention and manufacture of the automatic analyzer, too.

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(*Received*: 29 June 1999; *Accepted*: 18 August 1999) AJC-1839