

Effect of CdS on alum using photoacoustic spectroscopy

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Abstract . Photoacoustic (PA) spectra of CdS, alum and CdS-dispersed alum are recorded in a single beam PA spectrometer, using 1000 W tungsten halogen lamp. PA spectra of pure CdS and pure alum show an absorption edge at 515 nm, 1164 nm. PA spectra of 5% CdS-dispersed alum, 10% CdS-dispersed-alum and 15% CdS-dispersed alum show absorption edge at 2170 nm, 1650 nm and 1345 nm, respectively. Using these absorption edges, we have calculated the energy band gap and our result revealed that the energy band of CdS-dispersed alum is less than its constituents and energy band gap increases as we increase the amount of CdS.

Keywords : Photoacoustic spectroscopy, absorption edge, energy band gap.

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Photoacoustic spectroscopy (PAS) is one of the important branches of spectroscopy, which enables one to detect light-induced heat production following the absorption of pulsed radiation by the sample. Thus, PAS has been proved to be a very useful tool for determining the optical absorption spectra of any kind of sample [1]. The suitability of the photoacoustic (PA) technique lies in the fact that it can be applied irrespective of the physical state of the sample *i.e.* polycarbonate, solid, semi-solid, liquid, gel *etc.* [1,2]. PA spectra of the samples are very similar to the absorption spectra obtained by other spectroscopic methods. The PAS spectra are obtained directly from the heat, generated in a sample due to non-radiative absorption process [2,3]. In particular, it has been proved to be a very useful tool in the study of highly light-absorbing samples [4,5]. In cases where the photoacoustic signals were weak the cell was filled with helium gas to enhance the signal. This usually increased the gain by a factor of at least two [6].

Composite electrolytes are essentially two-phase materials prepared by the physical mixing of two materials (not necessarily high conductivity) resulting in an in-

creased conductivity in comparison to its constituents [7,8]. Recently, PAS emerged as a valuable tool for the study of energy band gap of such types of materials. Therefore in the present work, we have determined the energy band gap of following samples : (i) Pure alum, (ii) Pure CdS, (iii) 5% CdS in alum (iv) 10% CdS in alum, (v) 15% CdS in alum.

Alum $[(\text{NH}_4)_3\text{SO}_4\text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}]$ has been purchased from the market. Cadmium sulphide is prepared by the reaction of $\text{Cd}(\text{NO}_3)_2$ and Na_2S . To prepare a composite, alum and CdS are separately ground until we get a fine powder form. Now, we take an appropriate amount of alum and CdS by using digital chemical balance.

Light beam from a 1000 W tungsten halogen lamp was used to record the PA spectra of the samples. The light beam was modulated by a mechanical chopper (model SR 540, Stanford USA) and then, the required wavelength was selected by a monochromator (1/8 m Cornerstone, automatically controlled by computer, operated from TRACQ-32 monoutilty, programme) controlled by computer.

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The monochromatic modulated radiation was directed to the sample compartment of the PA cell through the quartz window as shown in Figure 1. PA signals are detected by the condenser (Radio shack, USA). These signals are then amplified by a two-stage pre-amplifier with a variable output by using a Preset (100 kΩ) and then fed to the lock-in-amplifier (model SR 530, Stanford, USA) for output display of amplitude and phase angles. The reference channel of the lock-in-amplifier was connected with the chopper for phase sensitive detection.

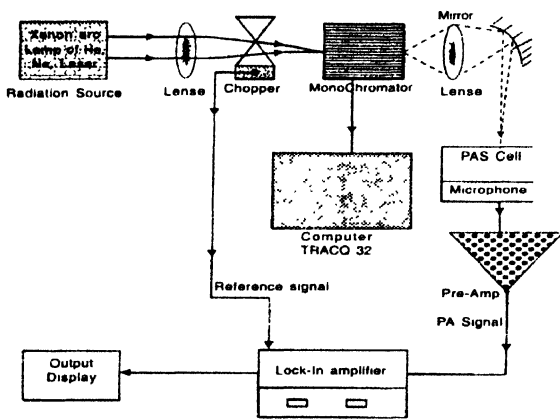


Figure 1. Schematic diagram of photoacoustic spectroscopy.

We have recorded the PA spectra using single beam PA spectrometer at fix chopper frequency (22 Hz) and by varying the wavelength of excitation source. It is clear from Figures 2–6 that the absorption is enhanced suddenly near a particular wavelength, which forms the band edge in the PA spectra of composite material. To estimate the correct value of band edge, tangent drawn at a point on either side of the absorption edge in the

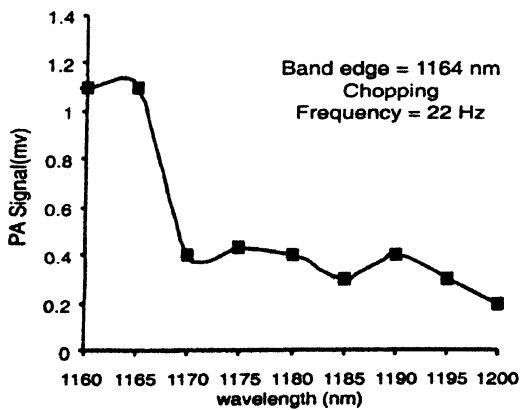


Figure 2. PAS of pure alum.

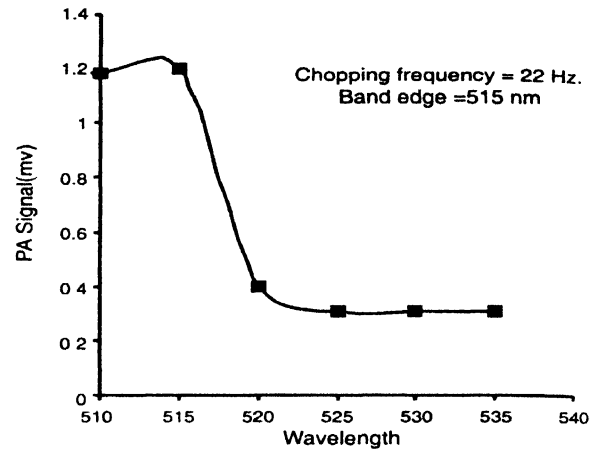


Figure 3. PAS of pure CdS.

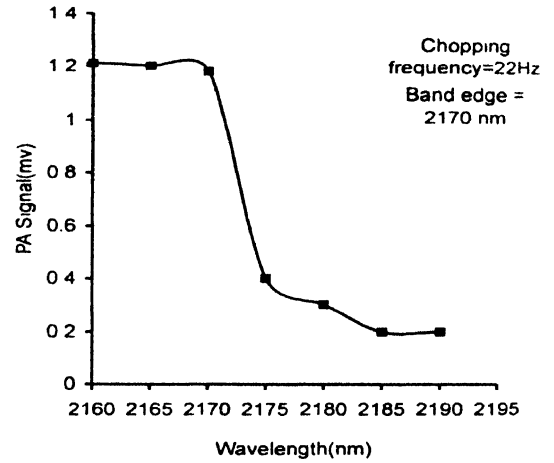


Figure 4. PAS of 5% CdS dispersed alum.

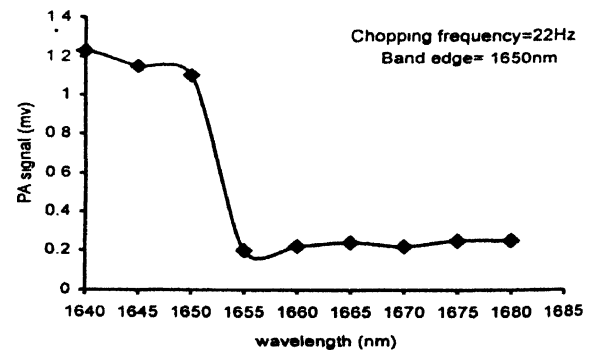


Figure 5. PAS of 10% CdS dispersed alum.

spectral curve, where the curve starts bending from its straight portion to form the edge. The cross sectional points of these tangent give the approximate value of wavelength corresponding to the band gap. The band gap

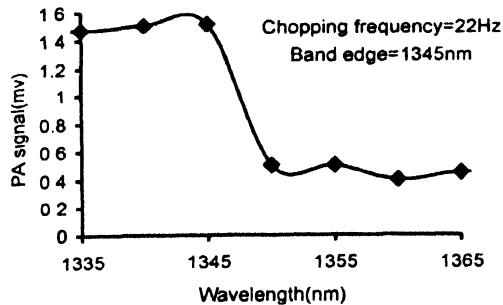


Figure 6. PAS of 15% CdS dispersed alum.

(E_g) of composite materials corresponding to this wavelength may be calculated from the following equation.

$$E_g = h\nu = \frac{hc}{\lambda}, \quad (1)$$

where, E_g is the energy band gap in Joules and λ is the wavelength of the absorption edge in meters. By putting the value of λ , the corresponding value of energy band gap may be calculated.

The value of λ corresponding to the absorption edge for five samples (pure alum, pure CdS, 5% CdS-dispersed alum, 10% CdS-dispersed alum, 15% CdS-dispersed alum) are determined from their PA spectra (Figures 2–6) and is tabulated in Table 1. Using these values of λ , energy band gap of these five samples are calculated by using eq. (1) and is tabulated in Table 1. It is

Table 1. Values of energy band gaps.

Sample	Absorption band edge (nm)	Energy band (eV)
Pure alum	1164	1.07
Pure CdS	515	2.4
5% CdS-dispersed alum	2170	0.57
10% CdS-dispersed alum	1650	0.75
15% CdS-dispersed alum	1345	0.92

clear from the table that the energy band gap of CdS-dispersed alum is less than its constituents. The energy band gap increases gradually as we increase the amount of CdS. Our results are in agreement with the result of Shahi *et al* [7,8] as the conductivity of CdS-dispersed alum increases in comparison to its constituents.

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