CHAPTER 5
STANDARDIZATION OF PA CELL AND COMPUTER BASED INSTRUMENTATION SYSTEM

5.1 INTRODUCTION:

In order to standardize the performance of the fabricated photoacoustic cell and computer based instrumentation system designed and developed by the author. Both the modulation frequency and temperature response of the cell is studied using a carbon black.

For standardization of the photoacoustic system a 4.5 mw (\(\lambda=650\) nm) laser diode is used as radiation source. The laser is chopped by TTL reference signal generated by lock-in amplifier. An electret microphone together with pre-amplifier and lock-in amplifier specially designed and fabricated by the author for the present work is used for photoacoustic signal detection. The PA cell calibration is carried out with a carbon black (prepared from the soot) as the reference sample. The carbon soot is coated on glass plate of 10mm diameter and thickness of 1mm is used.

5.2 STUDY OF THE PA CELL RESONANCE:

Before attempting to standardize the cell and the instrument, it is essential to determine the volume resonance of the PA cell. For this purpose, the carbon black is coated on the glass plate and the frequency response of the cell is studied at room temperature (of 25°C). Fig.5.1 shows the frequency response of the PA cell. From this response it is found to exhibit a strong resonance peak around 280Hz. This sharp increase in the amplitude of the signal around 280Hz indicates the characteristic volume resonance of the PA cell. The frequency response
Fig. 5.1 Frequency Response of the PA cell
characteristic observed for the cell designed by the author exhibits similar characteristic as reported by Vallbhan\textsuperscript{1} and Betchthold\textsuperscript{2}. Hence, care should be taken to operate the cell at modulating frequencies far removed from the resonance frequency to avoid the amplification of spurious (noise) signals which interfere with the PA signal. Hence, a modulation frequency of 70Hz which gives a good PA signal with liquid crystal samples has been chosen.

5.3 STANDARDIZATION OF THE SYSTEM WITH CARBON BLACK:

The standardization of the PA cell is done by measuring the photoacoustic amplitude and phase of the standard sample carbon, as a function of temperature. A microcontroller based PID precision temperature controller is employed to study the sample characteristics as a function of temperature.

Fig.5.2a and Fig. 5.2b shows the dependence of photoacoustic signal (both amplitude and phase as a function of temperature at a modulation frequency of 70 Hz when carbon black is used as the standard sample. The signal behaviour is studied from liquid nitrogen temperature (80K) to room temperature (300K). It is observed that the amplitude of the photoacoustic signal decreases continuously with increase of temperature, whereas the phase continuously increases with increase of temperature as can be seen from the figure. This behaviour is qualitatively in good agreement with the results reported by Vallbhan\textsuperscript{1} and Betchthold\textsuperscript{2}.

5.4 STANDARDIZATION OF THE SYSTEM WITH INDIUM:

The system is also standardized by taking Indium as another standard sample. The sample is kept in an aluminum crucible of 7mm diameter and with a depth of 1.5mm. The amplitude and phase of photoacoustic signal is measured by varying the temperature of the sample between 25° to 200°C with a precision temperature
Fig 5.2a Variation of Amplitude of Photocoustic Signal with Temperature (Carbon)
Fig. 5.2b Variation of Phase of Photocoustic Signal with Temperature (Carbon)
control system. The Fig. 5.3 and Fig. 5.4 shows the amplitude and phase of photoacoustic signal with temperature respectively. It is observed that there are sudden changes in the photoacoustic signal (both amplitude and phase) at 156.4°C which is at solid-liquid transition temperature of the Indium. It is also observed that there is a sharp dip in the amplitude at the transition temperature where as a sharp peak is observed in the phase graph. This shows the sample is thermally thick at this frequency. This observation exactly agrees well with the results reported by Korpium\textsuperscript{3} and Rosencwaig\textsuperscript{4}.

The above results obtained through the studies on the standard samples carbon and Indium, establish the reliability of the PA cell and the computer based Instrumentation system developed by the author for studying the phase transitions of the sample. Hence, the system is applied to study the phase transitions of various liquid crystal samples. The results of those are discussed in the foregoing sections.

### 5.5 THERMALLY THICK AND THERMALLY THIN SAMPLES:

i. If the thermal diffusion length \( l' \) is greater than the sample thickness \( l \), the sample is said to be thermally thin irrespective of the optical absorption length \( l_p \) and hence, the thermal properties of the backing material come into play.

ii. If the thermal diffusion length \( l' \) is less than the sample thickness \( l \), the sample is said to be thermally thick irrespective of the optical absorption length \( l_p \) and gives thermal properties of the sample but not that of the backing material. Keeping this observation in view, all samples are studied under thermally thick conditions.
Fig 5.3 Variation of Amplitude of Photocoustic Signal with Temperature (Indium)
Fig. 5.4 Variation of Phase of Photocoustic Signal with Temperature (Indium)
REFERENCES


***