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Application of Image Analysis to *p-(p'*-octyloxybenzylidene)-*p*-cyanoaniline Liquid Crystal for Statistical Parameters

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***Abstract*— Determination of statistical parameters is carried out in *p-(p'*- Octyloxybenzylidene) – *p* – Cyno aniline liquid crystal through image analysis technique in conjunction with polarizing optical microscope under crossed polarizers attached with a hot stage and a high-resolution camera. Sample exhibits enantiotropic nematic phase. Statistical parameters such as Mean, Standard deviation, Entropy, Energy, Contrast, and Homogeneity are computed as a function of temperature using matlab software. Temperatures obtained through image analysis technique are compared with differential scanning calorimetry technique and are found in agreement with pretransitional effect.**

Keywords: Liquid crystal textures: image analysis, Matlab, statistical parameters.

1. INTRODUCTION

In recent years, vivid research is in progress to get enhanced display devices with clarity and also at reasonable cost. Not only for display devices, liquid crystal applications are so many in different fields. So Work is going on rapidly, Many types of liquid crystal compounds have put forth to prove their work. Liquid crystals shows variety of phases with beautiful textures and these phases will be influenced by external fields like pressure, temperature, electric filed, magnetic field etc.[1,2]. LC materials possess low-dimensional crystallinity, the growth of the order parameter and the associated critical fluctuations [3,4] at the LC interfaces have become interesting areas of researching thermotropic liquid crystals the shape of molecules and structure of liquid crystals are influenced by the external parameters as well as chemical formation also. However the initial stage of study of liquid crystals involves the identification of phase transition temperatures. There are many techniques to find the transitions like Polarizing optical microscope (POM), differential scanning calorimeter (DSC), Differential Thermal Analysis (DTA), X- RD, Raman spectroscopy etc [5,6]. The most widely used technique in identification of phase transition temperatures is POM. DSC and DTA inform the presence of phase transitions in a material by detecting enthalpy and entropy changes that are associated with each phase transition. However, precise phase identification could not easily be made. The phase transitions causing small enthalpy and entropy changes are not identified in the procedures of DSC and DTA. Hence, DSC or DTA is used in conjunction with POM to determine the phase transitions temperatures of the samples as POM is a standard tool for liquid crystal compounds [7,8,9]. Researchers proposed an image processing and analysis methodology in conjunction with POM to investigate the phase transitions of liquid crystals [10,11].In present paper study of statistical parameters on *p-(p'*- Octyloxybenzylidene) *p*– Cyno aniline (OBCA) is carried out.

II. EXPERIMENTAL DETAILS

a. *Materials*

Liquid crystal *p-(p'*- octyloxy benzylidene) – *p* –cyano aniline (OBCA) was obtained from M/s Frinton laboratories, Inc, USA. The crystal structure of OBCA is given in Fig. 1.

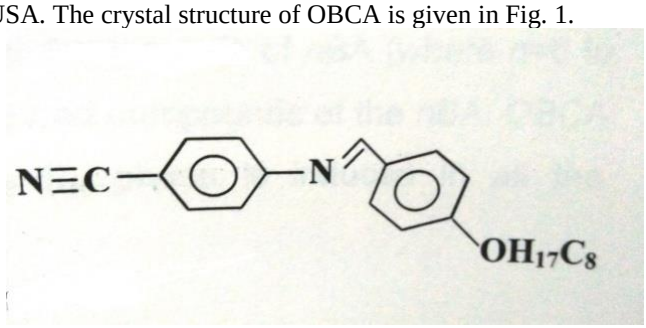

Fig.1: Molecural texture of OBCA.

b. Measurements

Liquid crystal sample is placed in to homogeneously perpendicularly aligned glass cell having the thickness of 5 microns . This cell is placed in to the hot stage which is connected to the temperature controller and digital temperature indicator. This total setup is to be placed in Meopta Polariszing optical Microscope (POM). Resolution of the microscope is to be adjusted to our eye site for keen observation of phase transitions. By giving the temperatures rise to hot stage we can perform the experiment. When sample is at room temperature it will be in crystal state, we have to give temperature rise very slowly characteristic textures of sample was recorded as images in high resolution Canon colour camera by using POM at crossed position as a function of temperature. Images have taken at regular interval of one degree rise of temperature. Each and every image was analyzed and converted into gray scale levels (for computation of statistical parameters) by using MATLAB (implemented on P4 1.6GHz with 512MB RAM computer) software version.7.0 [12] after reading and converting into gray scale image this image is used to image analysis particularly for statistical parameters. Textures are captured in equal intervals of temperature rise till the sample reaches the istotropic state, Same intervals have to follow in cooling of sample till it reaches the crystal state. It is better to capture images at the same viewing point in both heating and cooling. During this

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process OBCA undergo phase transitions(changes in textures, color, orientation, alignment of molecules etc) i.e., while heating crystalline state to isotropic state and while cooling isotropic state to crystalline state with intermediate nematic phase. There is wide range of image formats like JPEG, JPEG-2000, TIFF, PNG etc. The MATLAB software provides the necessary tools for various tasks of image analysis such as statistical analysis, feature extraction and property measurement. In the present study MATLAB software is used to compute the defined statistical parameters on the JPEG images.

III. RESULTS AND DISCUSSION

OBCA liquid crystal has undergone isotropic state to crystalline state through intermediate phase of nematic threaded structure Fig. 2(a). It exhibited enantiotropy of nematic phase [Fig. 2(b)] and phase transition temperatures were observed.

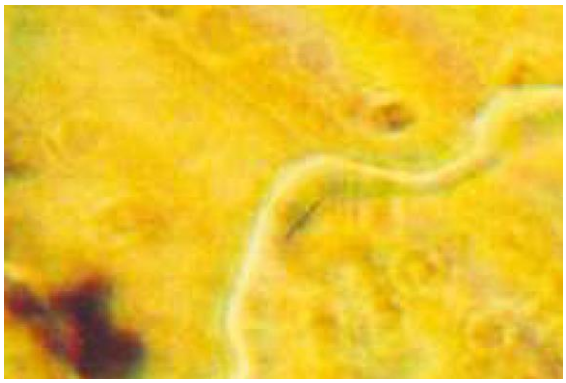
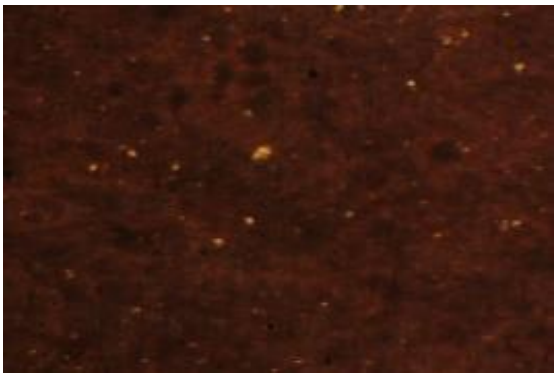


Fig. 2 (a): Nematic structure (threaded) in slide



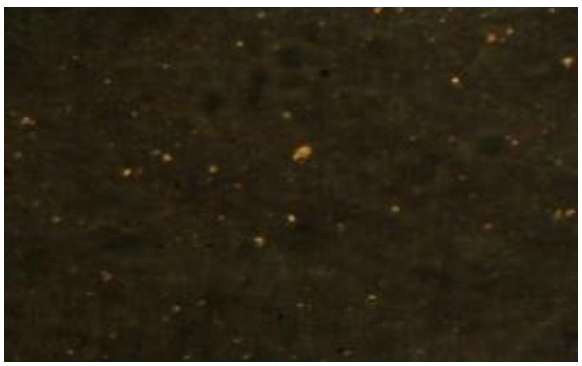


Fig. 2(b) Textures of OBCA under liquid crystal cell

Image analysis is the extraction of meaningful information from images mainly from digital images by means of digital image processing techniques [3]. This image analysis, analyze the orientation of molecules, textures, colour through images. Images have taken to both heating and cooling stages , plots have drawn for cooling stage only to avoid pramorphic defects. In this present work statistical parameters was derived they are Mean, Standarddeviation, Entropy, Energy, contrast correlation, Homogenity and the mentioned parameters was already discussed in our previous paper [7,9,12,13].

Statistical image analysis combines the technique that computes the statistical parameters of the image based on the grey-level intensities of the image pixels. An image (I) isof size m-by-n and it is composed of m pixels in the vertical direction and n pixels in the horizontal direction; i, j are horizontal and vertical coordinates of the image, respectively. The total number of pixels in the image is $m*n= N$, $0 \le i \le m$, $0 \le j \le n$. The defined statistical parameters are as follows:

Mean of an image is simply arithmetic average of the pixel values in the image. This can be obtained by summing up the all pixel values and divided by the total number of pixels.

$$\text{Mean}: \mu = \frac{1}{N}\sum_{i=1}^{m}\sum_{j=1}^{n} I(i,j) \qquad (1)$$

Temperature dependence of mean intensity levels of the present sample is shown in Fig. 3

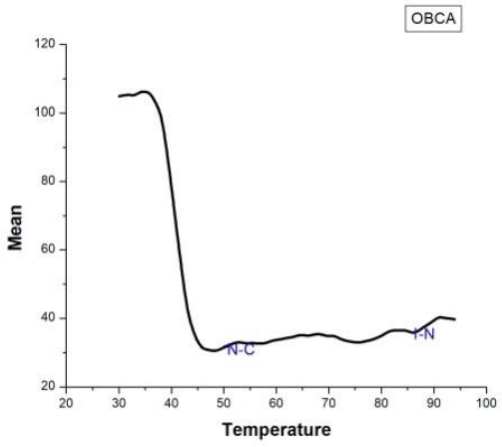


Fig. 3 Temperature dependence of mean

Standard deviation of the image is defined as the square root of the variance. Variance is defined as the variation of intensity around the mean value of image. If the variance value is closer to mean, the standard deviation is less.

Standard Deviation of the image:

$$\sqrt{\frac{\sum_{i=1}^{m}\sum_{j=1}^{n}(I(i,j)-\mu)^2}{N-1}} \qquad (2)$$

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The determined standard deviation values with temperature is shown in Fig. 4. The larger the standard deviation can be attributed to the wider the distribution of the molecules in the matter, greater the random error and the poorer the precision of the method, the smaller the standard deviation, the narrower and sharper the distribution of molecules in the matter, the smaller the random error, and the better the Precision of the method.

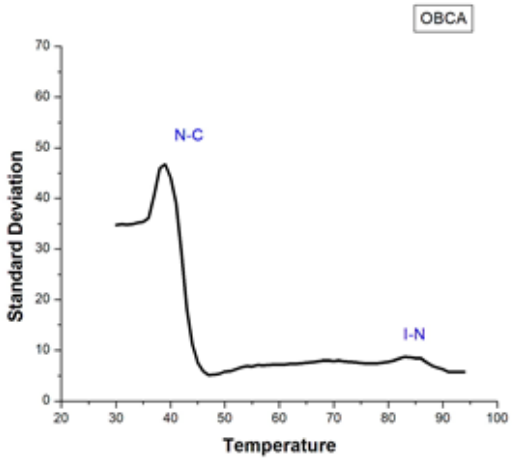

Fig. 4.Temperature dependence of standard deviation

Statistical measure entropy is the measure of randomness of the gray levels in an image, that is, it refers to how much randomly the gray levels are present in an image. The entropy of an image *I* is calculated by finding the probability *P* of a particular gray level value found in that image. Temperature dependence of entropy is shown in Fig. 5

Entropy of an image:

$$-\sum_{i=1}^{m}\sum_{j=1}^{n} p_{(i,j)} \log(p_{(i,j)}) \qquad (3)$$

where $p_{(i,j)}$ represents the number of occurrences of gray levels i and j in the given image.

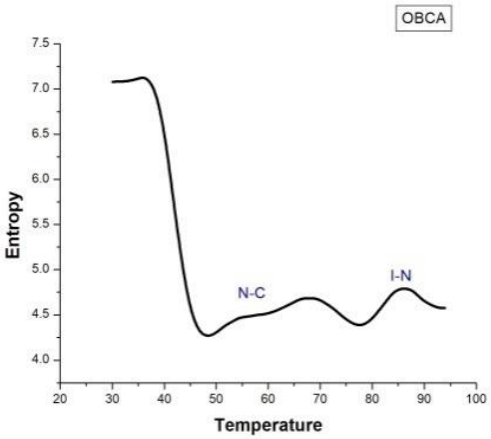

Fig 5 Temperature dependence of Entropy

Energy is a measure of uniformity in the texture. Maximum energy of the texture or image occurs when the grey level distribution of given image is either constant or a periodic uniform. Fig. 6 t shows temperature dependence of energy.

Energy of an image:= $\sum_{i=1}^{m}\sum_{j=1}^{n} GLCM(i,j)^2$ (4)

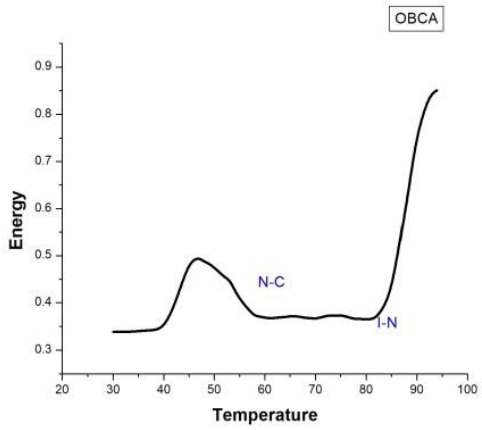

Fig 6. Temperature dependence of Energy

Contrast is major determinant of perceived picture quality. Contrast is created by the difference in intensity, i.e., the amount of reflected light from two adjacent surfaces. The degree of difference of an LCD monitor's ability to produce bright whites and the dark blacks decides the quality of display. If a picture has high CR, it is judged to be sharper and crisper. The temperature dependence of contrast ratio is shown in Fig. 7

Contrast: $\sum_{i=1}^{m}\sum_{j=1}^{n} (i-j)^2 GLCM(i,j)$ (5)

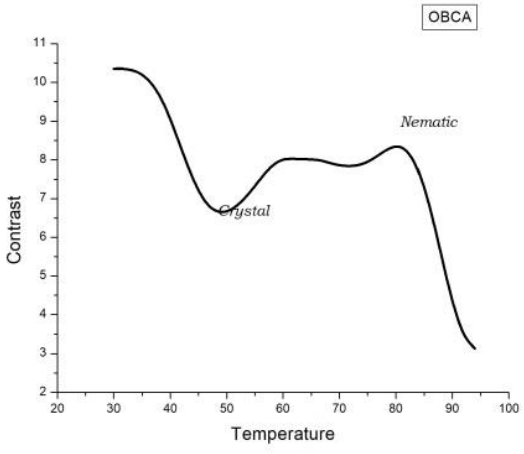

Fig 7. Temperature dependence of Contrast

Homogeneity means property of the material is uniform at every point without irregularities when the material is subjected to external field. Temperature dependence of homogeneity is shown in Fig. 8.

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$$Homogeneity = \sum_{i=1}^{m}\sum_{j=1}^{n}(P(i,j))^2 \quad \ldots.(6)$$

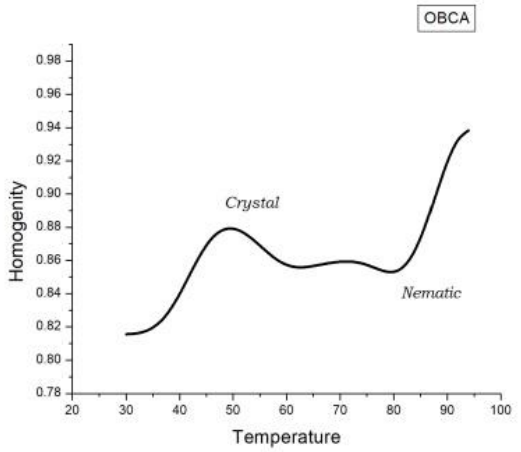

Fig 8 Temperature dependence of homogeneity

Statistical parametercvalues computed with the application of image analysis at existed phase of OBCA is given in Table 1.

Abrupt changes in graphs show the textural changes occurring in the sample due to rise in temperature and may be attributed to phase transition temperature.

Temperature dependence of heat flow of OBCA is shown in Fig. 8.

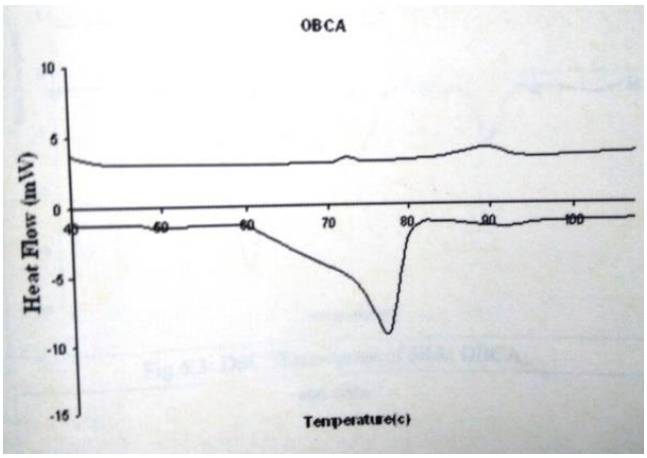

Fig 8. DSC thermogram of OBCA

Phase transition temperatures obtained from POM with DSC Fig. 8 are compared. Results are in agreement with pretransitional effects as shown in Table 2.

Table 1: Statistical parameters at existed phase in OBCA

Parameter	Statistical value
Mean	39
Standard Deviation	9.9
Entropy	4.8
Energy	0.35
Contrast	8.5
Correlation	0.63
Homogeneity	0.81

Table 2: Transition temperatures in ^oC

OBCA	Cr to N	N to Iso
POM (H)	81	94
DSC (H)	76	90
POM (C)	83.5	65
DSC (c)	80	61

IV. CONCLUSIONS

Present study demonstrates the determination of statistical parameters of OBCA liquid crystal by image analysis through polarizing optical microscope. We can also identity the phase transition temperatures through image analysis technique which is relable and sentive.

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