Volume 5, Issue 4, October 2018 ISSN: 2348-8565 (Online)
IJMERT
International Journal of Modern Engineering and Research Technology
Website: http://www.ijmert.org Email: editor.ijmert@gmail.com

Luminance Parameters Through Image Analysis Technique in Supramolecule PyB14A:*n*FA Mesogens

Ch. Kamalakar
Research Scholar,
Department of Physics
Kakatiya University,
Warangal (T.S.) [INDIA]
Email: kamalakarchathilla@gmail.com

C. J. Sreelatha
Associate Professor,
Department of Physics
Kakatiya University,
Warangal (T.S.) [INDIA]
Email: sree_phy_ku@yahoo.co.in

S. Sreehari Sastry
Professor & UGC BSR Faculty Fellow,
Department of Physics,
Acharya Nagarjuna University,
Guntur (A.P.) [INDIA]
Email: sreeharisastry@yahoo.com

D. M. Potukuchi
Professor
Department of Physics
Jawaharlal Nehru Technological University
Kakinada (A.P.) [INDIA]
Email: dakshinamurthy_potukuchi@gmail.com

Abstract

The aim of the paper is to compute the display device quality parameters of supramolecule PyB14A:nFAs synthesized from nonmesogenic moieties and nonmesogenic long-chain-bearing aliphatic acids (nFAs where n = 14 and 16) through image analysis technique in conjunction with polarizing optical microscopy (POM) under crossed polarizers attached with a hot stage and a high-resolution colour camera. Luminance and its related parameters such as visual acuity, grey shades and luminance contrast ratio are computed for these liquid crystals by analyzing the textural optical transmittance intensities of samples as a function of temperature at 635 nm (red), 530 nm (green) and 475 nm (blue) wavelengths using MATLAB software. Liquid crystal phase transition temperatures are characterized by image analysis and compared with differential scanning caloriemetry technique. Temperature dependence of luminance and its related parameters are discussed for identifying the suitability of liquid crystal compound for better selectivity of display.

Keywords:— *Liquid crystal textures; Image analysis, optical transmittance; Luminance related parameters.*

I. INTRODUCTION

Applications of liquid crystals depend on its physical properties, such as phase transitions, device optical parameters, etc., and also the nature of their response to external conditions [1, 2]. The human eye is very good at recognizing distinctive patterns of shapes and colours. The observation of optical texture changes under the polarizing optical microscope [POM] has usually been the first technique employed to identify the phase transition temperatures of any new materials. This is a subjective and qualitative approach, and an objective and quantitative technique would be valuable [3].

Synthesizing various liquid crystal complexes from the mixtures of mesogenic–mesogenic materials, mesogenic– non-mesogenic materials and non-mesogenic – non-mesogenic materials in different molecular ratios is a very significant area of the liquid crystal research [4-7]. In such complexes, the molecules of the compounds which involve the noncovalent and covalent interactions follow the process of self-organization [8, 9].

Furthermore, supramolecule formed through the hydrogen bond has a striking influence on physical properties such as melting and clearing temperatures, enthalpies, entropies [10], quenching of phases and inducing new phases with the wide thermal span [11, 12].

In continuation of our work on image analysis in ferroelectric liquid crystals for luminance and its related parameters [13], the present communication deals with the application of image analysis in conjunction with POM in determining luminance and its related parameters like visual acuity, grey shades and luminance contrast ratio on hydrogen bonded liquid crystals. They are computed by analyzing the textural optical transmittance intensities of samples as a function of temperature at 635 nm (red), 530 nm (green) and 475 nm (blue) wavelengths using MATLAB software in homogeneously aligned liquid crystals which are synthesized with two non liquid crystals formed through hydrogen bond, viz., PyB14A:nFAs where n=14 and 16.

II. Experimental

Non liquid crystals (4-pyridyl)-benzylidene -4'-*n*-tetradecyl aniline (PyB14A) and long-chain aliphatic carboxylic acid (FAs) nFAs (for *n* = 14 myristic acid and 16 palmitic acid) possessing different alkyl chain lengths are taken for synthesis to get liquid crystals through hydrogen bond between the two moieties PyB14A:nFA where n = 14 and 16 as reported in [14]. The molecular structure is shown in figure 1.

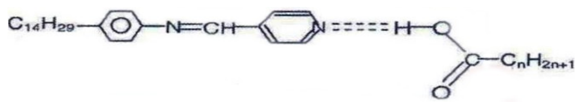


Figure 1 : Molecular structure of PyB14A:nFA

where n = 14 and 16

An indium tin oxide coated homogeneous cell of dimensions 5 mm× 5 mm with 6 μm spacing (tolerance ±0.2μm), was obtained from Instec, USA. The liquid crystal samples are injected into cells by capillary action on heating in isotropic state. The different phase transitions are observed in heating and cooling cycles. The textural characterization of phases exhibited by the present PyB14A:nFAs is carried out with the help of a Meopta polarizing optical microscope (POM) in conjunction with an heating stage as described by Gray [15], and a high resolution Canon colour camera (Digital Rebel XS EOS 1000D) and the details are found elsewhere [16].

Textures of the samples are recorded at a cooling rate of 0.2°C min under crossed polarizer condition. The texture images detected by the camera has a resolution of 2816 × 1880 pixels and the intensity values of the pixels ranges from 0 to 255. The image dimensions were selected to be 256 × 256, and the images were stored in the computer for further processing.

MATLAB software is used to compute the optical transmission of the samples in three monochromatic image planes, red, green and blue. These components showed the greatest variations in intensity. The programme was coded in MATLAB for computational analysis of textures. The colour image has a resolution of 2816 × 1880 pixels which represents 24 bit true colour pixel tone in total and the intensity values range from 0 to 255 in each red (R), green (G), blue (B) colours. However, the translated gray scale image is used here for analysis. The size of images is selected for 256. The program has been coded using MATLAB software for analysis of textures which is an efficient tool for computational analysis [17, 18].

Luminance (L): It is the intensity of light emitted from a surface per unit area in a given direction. It is also known as luminance signal of a composite television signal which carries information on the brightness of the image. Luminance is often used to characterize emission or reflection from flat and diffuse surfaces. The luminance indicates the amount of luminous power that is detected by an eye looking at the surface from a particular angle of view. A luminance level equal or higher than 85 candel per square meter is the minimum threshold level recommended [19]. Luminance variability is assessed under given (nominally) uniform, full screen images with gray levels from black (i.e., RGB = 0, 0, 0) to white (i.e., R,G.B = 255, 255, 255)

$$L = 0.2989 * \frac{1}{N}\sum_{i=1}^{m}\sum_{j=1}^{n} IR(i,j) + 0.587 * \frac{1}{N}\sum_{i=1}^{m}\sum_{j=1}^{n} IB(i,j) + 0.1140 * \frac{1}{N}\sum_{i=1}^{m}\sum_{j=1}^{n} IG(i,j) \quad ....(1)$$

where IR = intensity of Red light in image.

IB = intensity of Green light in image.

IG= intensity of Blue light in image.

Visual acuity: Visual system special resolution is expressed by Acuity. It is defined in this standard as a measurement of the ability to recognize black, high-contrast image on a white background. It can also be seen as sharpness which is measured in cycles per visual degree. Human vision performance depends on luminance [20]. Under low brightness conditions, acuity drops significantly and spatial detail is lost even for healthy observers. In Visual science the term Visual Acuity refers to the ability of an observer to resolve fine pattern in detail. Acuity is usually specified in terms of decimal acuity, defined as the reciprocal of the smallest resolvable pattern detail in minutes of arc of visual angle. "Normal" or average acuity is considered to be 1.0 (a resolution of 1min arc), although many young adults have a decimal acuity slightly better than this [21]. The visual acuity score of an individual is to be expressed as the reciprocal of the angular size of the critical detail within the smallest optotype that can be correctly recognized by the individual. The luminance is not constant over the whole image, but may change locally [22]. The following relation determines the luminance to maximal resolvable frequency from Shaler's data:

$$f(L) = 25.72+17.25 * \tan^{-1} [1.4 \log_{10} (L) + 0.35] \quad ....(2)$$

***Grey shades**:* Based on the idea of brightest areas being white and the darkest areas being black, brightness levels between the two extremes are referred to as gray levels or shades and the ability to display them is termed as gray scale. The number of gray scales is determined by contrast level and ability of human visual perception. Our visual system reacts to the changes in brightness level as a logarithmic function. Hence very small difference in brightness may not be perceived. The number of grey shades (G) that can be displayed can be defined as a logarithmic function based on contrast ratio (G) [23,24]

$$G= 1+(1/\log (\sqrt{2}))* \log (L_{max} / L_{min}) \quad ....(3)$$

Luminance contrast ratio (LCR): LCR is another major determinant of perceived picture quality. If a picture has high LCR, it is judged to be sharper and crisper than a picture with lower LCR. Contrast is created by the difference in luminance, i.e., the amount of reflected light, reflected from two adjacent surfaces. Contrast is important in systems that automate the selection of colours. The degree of difference of an LCD monitor's ability to produce bright whites and the dark blacks decides the quality of display. It is the ratio of luminance between the brightest white and the darkest black that can be produced. When the darker surface is black, it reflects no light, hence the ratio is 1. Contrast is usually expressed as percentage, (and then the ratio is multiplied by 100). The maximum contrast is thus 100%. Contrast ratio is a quantity intended to create with the perceived brightness contrast, usually defined by one of a number of formulae which involve Luminance [25]. Greater screen brightness is achieved with a contrast ratio greater than 5:1. In outdoor environments under the shade, such a display can provide an excellent image quality. Contrast ratio (CR) is the ratio of luminance between the brightest “white” and the darkest “black” that can be produced on a display.

$$\text{Luminus Contrast Ratio (LCR)} = \frac{(L_{max} - L_{min})}{(L_{min})} \ldots\ldots (4)$$

where L_{max} = Maximum value of luminance,
L_{min} = Minimum value of luminance
with $1 \leq CR \leq \infty$ CR=1 means no contrast

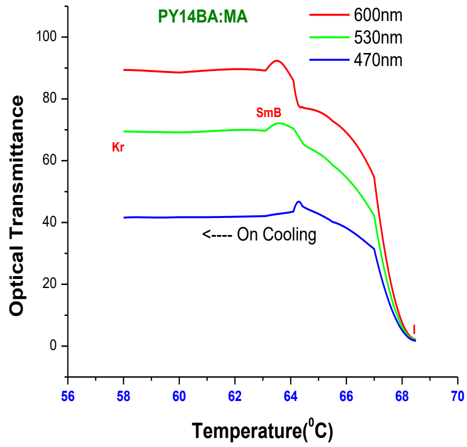
III. Results and Discussion

Thermo optical properties [26-28] of hydrogen bonded liquid crystals PyB14A:*n*FAs where *n*= 14 and 16 have been discussed at three wavelengths 600nm, 530nm, 470nm.

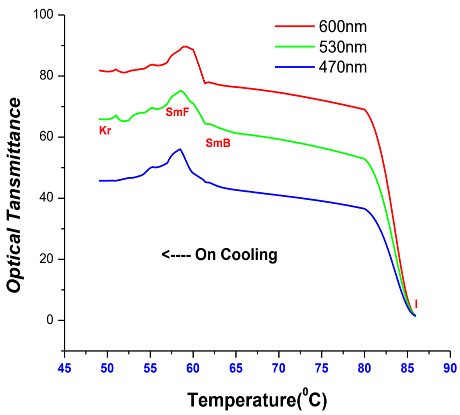
Optical transmittance: Transmittance of a material is the proportion of the incident (approaching) light that moves all the way through to the other side. Transmittance of HBLC’s was measured by computing the average transmitted intensity of the image texture recorded under the crossed polariser condition [29], as in Equation (5):

$$\text{Optical transmittance} = \frac{1}{N}\sum_{i=1}^{m}\sum_{j=1}^{n} I(i,j) \ldots\ldots (5)$$

Where *I(i,j)* is the image intensity value observed at location *(i, j)* from the crossed polarization component of the texture image. Between crossed polarizers the value of the optical transmittance is zero in the isotropic liquid phase of the sample. During cooling the value of optical transmittance increases close to the isotropic–SmB transition and is at a maximum at the SmB temperature interval in n=14, where as in n=16 optical transmittance increases slowly near to SmB transition and maintains thermal stability for a long range of temperature variation and then there is a sudden shoot up of optical transmittance at SmF phase transition as shown in figure 2 (a) and (b) fpr m=14 and 16 respectively.

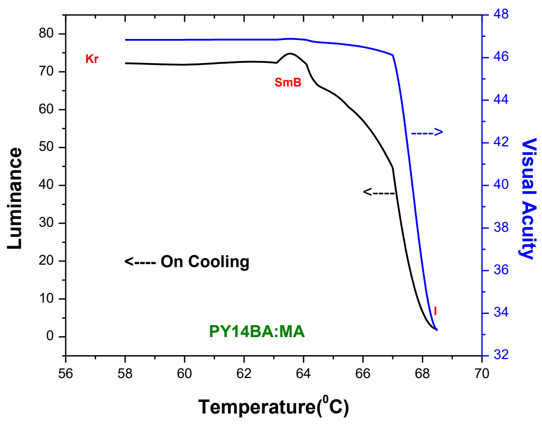


2(a)

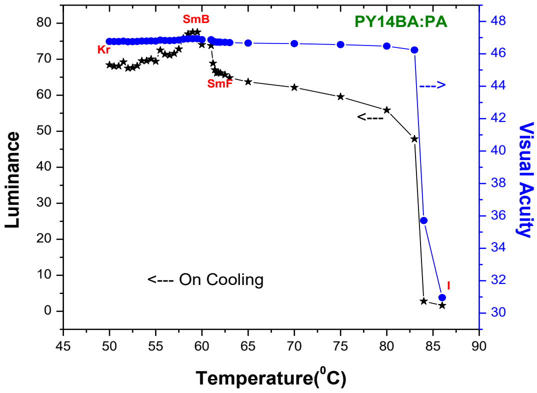


2(b)

Figure 2. Temperature dependence of Optical transmittance of PyB14A:nFA (a) where n = 14; (b) where n = 16 (Kr:Crystal; sm B –Smectic B; sm F–Smectic F; I:Isotropic).



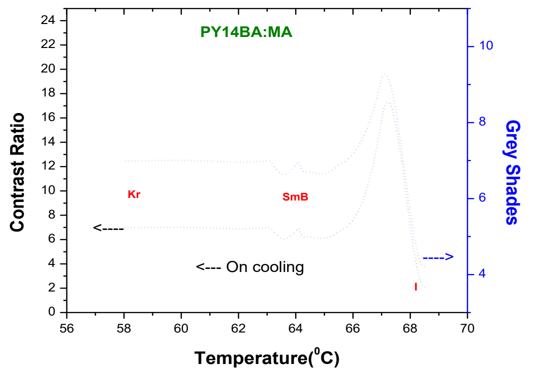
3(a)



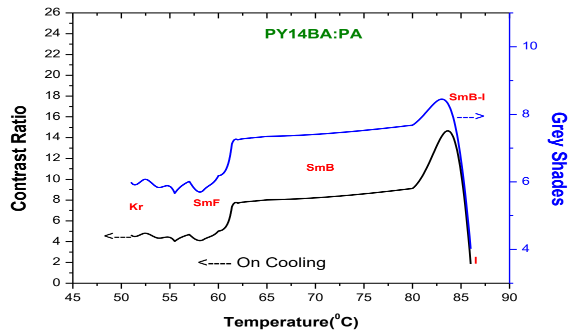
3(b)

Figure 3: *Temperature dependence of 3(a) Luminance and 3(b) Visual Acuity PyB14A:nFA for n=14 and n=16 respectively.*

Variation of Luminance and Visual acuity with temperature in PYB14A:nFA for n=14 and *n*=16 is calculated from equation's (4) and (5) respectively. From Figure 3(a) and 3(b) The temperatures at the clearing point vary greatly from material to material and it is observed that both the value of luminance and visual acuity is a minimum in the isotropic state for both n=14 and 16 supramolecules. In this phase the molecular orientation is random and there is no luminance and visual acuity. On cooling of the sample *n*=14 supramolecules there is a sudden increase in luminance in the biphasic region of the I–SmB phase temperature interval and in n=16 HBLC there is a slow increase in luminance in biphasic region of I-SmB phase and maintains stability for long interval of time and there is again a sudden increase of luminance from SmB-SmF and slight decrease in luminance till crystalline state. This is due to the fact that the luminance exists in the SmB phase as there is layered alignment of the molecules. Sharp texture transformations of SmB–SmF and SmF–Kr give abrupt changes in the values of Luminance. Luminance values are higher in n=16 compare to n=14. On cooling visual acuity increases rapidly with the decrease of temperature and reaches to saturation. Both the samples are giving good standards of visual acuity at higher luminance. It is drawn that from graph Visual Acuity is more for n=14 compound in comparison to n=16. So, to get a better visual acuity levels n=14 compound is preferable to n=16 in display devices.



4 (a)



4 (b)

Figure 4: 4(a) and 4(b) shows Variation of Contrast Ratio and Grey Shades with temperature in PYB14A:nFA for n=14 and n=16 respectively.

Gray shades, Contrast Ratio in terms of luminance are calculated from equation (6) and equation (7) respectively and these variations with respective to temperature are observed from figure 4(a) and 4(b). Gray shade values (G) and Contrast ratio values for both the compounds shows a sudden shoot up and a drop down in gray shade values during the SmB, SmB-I phases in n=14 and during the SmB, SmF, SmB-I phases in n=16 respectively. Both grey shade values and luminance contrast ratio is minimum at isotropic phase. According to the literature, the average G maintained with the samples is around 5.6. The G is better for both the samples are recorded showing more than standard value of 5.6. Hence, both the samples are recommended for the liquid crystal display (LCD) panel. As the sample with n=14 shows higher value of Grey Shades compare to n=16. So n=14 is preferable to n=16 to have the display with better grey shaded values. From figure 4(a) and 4(b) n=14 compound is more preferable relatively to n=16 for better contrast ratio. The comparison of weber contrast with the CR indicates that there is only one unit difference in their values. Both the samples are having contrast ratio greater than standard values for better human eye perception.

These computations and the plots are drawn for the thermo optical and display device standard parameters as a function of temperature. Fluctuations and abrupt increase or decrease in the value of optical parameters of homogeneously aligned samples are thus due to the fact that, on cooling of sample from its isotropic phase, the realignment of molecules in their respective phases as a function of temperature showed the sharp textural transformations of different phases. These textural transformations bring variations in the transmitted intensities of the images, which are useful for studying the optical properties and phase transitions of the samples. When compared to the other techniques given in the literature the complexity of this method is much lower in terms of time and also expense. Like other approaches, there is no need to arrange different setups, and it is sufficient to have the image textures of liquid crystals recorded under crossed polarizers from solid state to isotropic liquid state to compute the defined parameters. This image analysis method is therefore easy and a simple approach for observing the behavior of the optical parameters of different liquid crystals as a function of temperature.

The differential scanning calorimetry (DSC) thermograms recorded for heating and cooling cycles at a scan rate of 5^{o}C per minute are presented in figure 5 (for n=14 as representative). The data of transition temperatures as identified by the peaks and the corresponding enthalpy (ΔH) values are presented both in cooling and heating cycles in Table 1. The observation of a single peak in the DSC of n = 14 and 16 compounds is found to agree with the data of the present POM studies to support the monotropic occurrence of SmB cryst phase. The ΔH values observed across I–SmB cryst and SmB cryst–SmF transitions are found to be relatively higher than the reported [30,31] enthalpy values involving liquid crystals phases of lower dimensionality. But the observed ΔH values are found to be comparable with those reported [32,33] across liquid crystals transitions involving SmB crystal or SmF phase.

Hence, the observed higher values of ΔH are argued due to the involvement of LC phases with 3D structure. Nevertheless, the finite and nonzero ΔH values observed across Iso–SmB cryst and SmB crys–SmF transitions infer the first-order nature of the LC transitions.

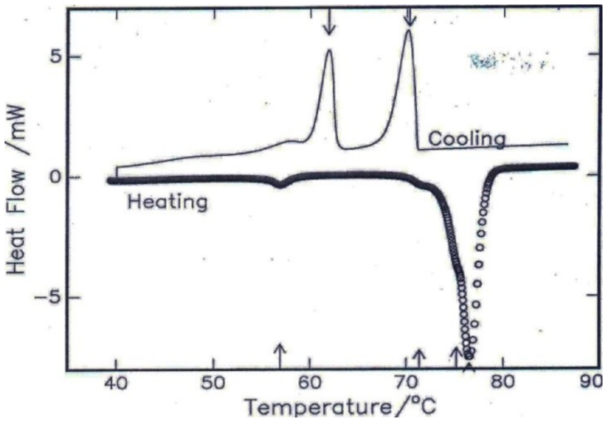


Figure 5: DSC thermogram of PyB14A:nFA where n=14

Table 1: Phases and Phase Transition Temperatures of PyB14A:*n*FA Where *n* =14 and 16

Py-B14A: nFA where n=	phases	Phase Transition Temperatures Image Aanalysis / DSC
14	I – Sm B -Kr	68.0 - 63.50 - 54.0 / 67.4 - 64.60 - 55.0
16	I – Sm B – Sm F - Kr	71.5-61.8-59.5 / 70.1-62.0-59.0

(Kr:Crystal; sm B – Smectic B; sm F – Smectic F; I:Isotropic).

Phase transition temperatures obtained through temperature dependence of statistical parameters [34] and also through optical parameters [35] on PyB14A:nFA samples agree with the present study which is carried out through temperature dependence of luminance and related parameters.

IV. CONCLUSIONS

Temperature dependence of luminance and its related parameters, like visual acuity, grey shades and luminance contrast ratio are computed by image analysis technique in hydrogen bonded supramolecule liquid crystals PyB14A:nFA where n= 14 and 16 and also the temperature dependence of these parameters are exhibiting phase transition temperatures which are same in addition to the phase transition temperature values obtained from differential Scanning Caloriementry technique.

ACKNOWLEDGEMENTS

One of the author (SSS) is grateful to UGC BSR Faculty Fellow research grant No.F.18 -1/2011 (BSR), dated 04-01-2017, New Delhi for providing financial assistance. The authors are grateful to Prof. M. Srinivasulu, Manipal University in synthesizing the compounds.

REFERENCES:

[1] Demus, D.; Goodby, J.; Gray, G.W.; Spiess, H.W.; Vill, V. Physical Properties of Liquid Crystals; Wiley-VCH, Singapore, 1999.

[2] Singh, S. Liquid Crystals Fundamentals; World Scientific, Singapore, 2002

[3] Sreehari Sastry S, Sandeep Kumar, Vindhya Kumari T, Mallika K, Gowri Sankara Rao B, and Ha Sie Tiong, Liquid crystal parameters through image analysis, Liq. Cryst.,39(12), 2012, 1527–1537

[4] Liquid crystals and advanced organic materials, Department of chemistry, University of York [Internet]. Available from: http://www.york.ac.uk/chemistry/staff/academic/d-g/jgoodby

[5] Paleos CM, Tsiourvas D. Supramolecular hydrogen bonded liquid crystals. Liq Cryst. 28, 2001, 1127–1161.

[6] Goodby JW, Gortz V, Cowling SJ, Mackenzie G, Martin P, Plusquellec D, Benvegnu T, Boullanger P, Lafont

D, Queneau Y, Chambert S, Fitremann J. Thermotropic liquid crystalline Glycolipids,. J Chem Soc Rev. 36, 2007, 1971–2032.

[7] Cook AG, Wardell J L, Brooks N J, Seddon J M, Martínez-Felipe A, Imrie CT. Non-symmetric liquid crystal dimer containing a carbohydrate-based moiety, Carbohydrate Res. 360, 2012, 78–83.

[8] Lehn JM. Supramolecular chemistry-scope and perspectives molecules, supermolecules, and molecular devices. Angew Chem Internat Ed (English). 2, 1998, 89–112.

[9] Kato T, Demus D, Goodby J, Gray GW, Spiess HW, Vill V, editors. Handbook of liquid crystals. Weinheim: Wiley-VCH; 1998.

[10] Martinez-Felipe A, Lu Z, Henderson PA, Picken SJ, Norder B, Imrie CT, Ribes-Greus A. Synthesis and characterisation of side chain liquid crystal copolymers containing sulfonic acid groups. Polymer. 53, 2012, 2604–2612.

[11] Kato T, Frechet JMJ. Stabilization of a liquid crystalline phase through non-covalent interaction with a polymer side chain. Macromolecules. 22, 1989, 3818– 3819.

[12] Ravi Shankar Kumar C, Jha A, Sreehari Sastry S. Induced crystal G phase of Liquid crystalline amide through Intermolecular hydrogen bonding. J Non- Cryst Sol. 356, 2010, 334–339.

[13] Sreehari Sastry, S, Sailaja, M, Lakshminarayana S and Ha S.T., Computation of Liquid Crystal Display device parameters through image analysis, IJERA 7(7-part9), 24-31, (2017)

[14] Muniprasad. M, Srinivasulu. M, Chalapathi. P.V & Potukuchi. D.M. Induction of Liquid Crystalline Phases and Influence of Chain Length of Fatty Acids in Linear Hydrogen-Bonded Liquid Crystal Complexes. Mol. Cryst. Liq. Cryst..557, 2012, 102 –117.

[15] Gray, W. Molecular Structure and Properties of Liquid Crystals; Academic Press: New York, USA, 1962.

[16] Sreehari Sastry S., Ha S.T., Gowri Sankara Rao B, Mallika K & Vindhya Kumari T, Optical properties of a mesogen by image analysis. Liq. Cryst.,39(11) 2012, 1414–1419

[17] Gonzalez RC, Wood RE, Eddins SL. Digital image processing using MATLAB. Dorling Kindersley (India) Pvt. Ltd., Delhi, 2004.

[18] Gonzalez RC, WintzP.Digital Image Processing- Reading. USA :Mass, Addison-Wesley

[19] Karthikeyani V, Duraiswamy K, Kamalakkannan P. Conversion of Gray-scale image to Color Image with and without Texture Synthesis. IJCSNS. 7(4)., 2007

[20] Castellano, J.A. Handbook of Display Technology. San Diego :Academic Press.;1992.

[21] Ward Larson G, Rushmeier H, Piatko C. A visibility matching tone production operator for high dynamic range scenes. IEEE TVCG. 3(4), 1997, 291

[22] Shaler S. The relation between visual acuity and illumination. J Gen Psychology. 11(3), 1928, 255.

[23] Delphine T, Odile Brosseau L, Jocelyn F, François V D. Maturation of the sensitivity for luminance and contrast modulated patterns during development of normal and pathological human children. Vision Research. 47(12), 2007, 1561–1569.

[24] Jacko JA. The Human-Computer Interaction: Handbook, Fundamentals, Evolving Technologies, and Emerging Applications. CRC Press.2007.

[25] Shinya T, Hiroshi Yak A, Norimak H, Yasuhiko N, Yoshio M, Akiko Hattori. A preliminary study for exploring the luminance ratio of liquid -crystal displays required for display of radiography. Radio Physics Technology. 7, 2014, 73-78.

[26] Bhat, S. G., Srinivasulu, M., Girish, S. R.. Padmalatha, R. Bhagavath, P., Mahabaleshwara, S.,Muniprasad, M., & Potukuchi, D. M. Influence of moieties and chain length on the abundance of orthogonal and tilted phases of linear hydrogen-bonded liquid crystals, Py16BA:nOBAs, Mol. Cryst. Liq. Cryst., 552, 2012, 83–96.

[27] Gray, G. W., & Goodby, J. W. Smectic Liquid Crystals – Textures and Structures, Leonard Hill: London. (1984)

[28] Canon, Rebel XS EOS 1000D, Review and microscope application.

[29] Manohar, R.; Srivastava, A.K.; Jyotishman, S.J.P; Prajapati, A.K.; Bonde, N.L. Dielectric, optical and thermodynamical properties of liquid crystal sample exhibiting SmA phase Int. J. Phys. Sciences 1, 2006, 147–153.

[30] Rao, N. V. S., Potukuchi, D. M., & Pisipati, V.G. K. M. Phase Transitions in N(p-n- Butoxybenzylidene) p-n-Alkyl Anilines: Density and Refractive Index Studies (1991).Mol. Cryst. Liq. Cryst.,196,71–87

[31] Alapati, P. R., Potukuchi, D. M., Rao, N. V. S. & V. G. K. M. Phase Transition and Structural Investigations in 50.5, 50.6 and 50.7. Liq. Cryst., 3, 1988, 146

[32] Rao, P.B., Potukuchi, D.M., Murthy, J.S. R., Rao, N. V. S., & Pisipati, V. G. K. M. Phase Transition Studies in Some 4-n-Alkyl-N-(4-n-Alkyloxy-Benzyli- dene)- Anilines, Cryst. Res. Tech. 27, 1992, 839–849.

[33] Rao, N. V. S., Rani, G. P., Potukuchi, D. M., & Pisipati, V. G. K. M. Dilatometric Study of the Isotropic-Smectic F Transition of 10O.14, (1994).Z.Naturfosch.,49a, 559–562.

[34] Kamalakar,Ch., Sreelatha, C. J., Potukuchi D.M.and Sreehari Sastry, S., Phase transition temperatures through temperature dependence of statistical parameters by image analysis on Py14BA:nFA mesogens, IJIRSET, 7(9) 10001 - 10006 (2018)

[35] Kamalakar, Ch., Sreelatha, C. J., Mallika K.,, Potukuchi D.M. and Sreehari Sastry, S., Application of Image Analysis Technique to Supramolecule PyB14A:nFA Liquid Crystals Through Hydrogen Bond, IJIRSET 7(10), 2018, 10807- 10813