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Synthesis, Characterization and HF Technique to Reduce Multiplicative Noise in Nano-dispersed LC Compounds

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Abstract: Synthesis and characterization are carried on 70µl citrate capped gold nanoparticles dispersed in N-(p-n-nonyloxy benzoic acid Liquid Crystalline compounds (LC). Further homomorphic filtering (HF) technique is used to reduce the multiplicative noise in the image. This technique provides frequency domain procedure to improve the appearance of an image by gray level range compression and contrast enhancement. Polarizing microscope connected with hot stage and camera is used to capture the textures of the compounds. The compound with dispersion of 70 µl exhibits same NC phases as compared with the pure 9OBA with reduced clearing temperature as expected and nematic thermal ranges are increased while performing DSC and POM.
Keywords: Synthesis, Homomorphic Filtering, Polarizing Microscope (POM), Differential Scanning Calorimeter (DSC), Nano dispersion, Illumination, Multiplicative Noise, Reflectance.

Introduction:

Liquid crystals are intermediate states of condensed matter; they combine long range positional or orientation order along some directions of space (like in a crystal) and liquid like disorder along other direction. Recent studies of LCs doped with nanoparticles have given rise to a number of practical applications like LC display techniques and received much attention in the recent years because of their ability to transfer their long range orientational order on the dispersed materials such as nano particles and various colloids [1-7]. LCs are now playing a very significant role in nanoscience and nanotechnology (8-11). Homeotropic alignment of liquid crystals has applications in liquid crystal display technology, such as high information display devices, large area LCD TVs and digital display devices used in the medical field like digital medical imaging [12].

Homomorphic filtering [13] technique is one of the important method used for digital image enhancement, especially when the input image suffers from poor illumination conditions. This filtering technique has been used in many different imaging applications, including biometric, medical and robotic vision. According to this approach, input signal is assumed to consist of two multiplicative components: background and details. Homomorphic filtering works in frequency domain, by applying a high-pass type filter to reduce the significance of low frequency components.

Homomorphic filtering:

One of the popular methods used to enhance or restore the degraded images by uneven illumination is by using homomorphic filtering. This technique uses illumination-reflectance model in its operation. This model consider the image is been characterized by two primary components. The first component is the amount of source illumination incident on the scene being viewed *i*(*x*, *y*). The second component is the reflectance component of the objects on the scene *r*(*x*, *y*). The image *f*(*x*, *y*) is then defined as

$$f(x, y) = i(x, y) \cdot r(x, y) \quad \text{--- (1)}$$

In this model, the intensity of *i*(*x*, *y*) changes slower than *r*(*x*, *y*). Therefore, *i*(*x*, *y*) is considered to have more low frequency components than *r*(*x*, *y*). Using this fact, homomorphic filtering technique aims to reduce the significance of *i*(*x*, *y*) by reducing the low frequency components of the image. This can be achieved by executing the filtering process in frequency domain. In order to process an image in frequency domain, the image needs first to be transformed from spatial domain to frequency domain. This can be done by using transformation functions, such as Fourier transform.

Goal of Homomorphic filtering is to suppress low frequencies associated with input image so that the net effect is enhancement

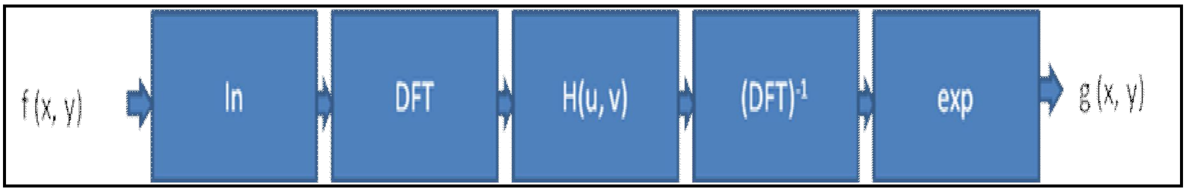

Fig. 1 Steps in homomorphic filtering

To achieve the above mentioned goal, a filter has to be designed in such a way that illumination component is suppressed and reflectance is enhanced as shown in Fig.1. Low frequencies of Fourier transform of log of an image are associated with illumination and high frequencies are associated with reflectance [14-15]. Although these are approximate associations, but can be used for image enhancement. Transfer function is controlled in such a way that low frequencies are attenuated and high frequencies are passed untouched Fig. 2. To parameters r_L and r_H are chosen

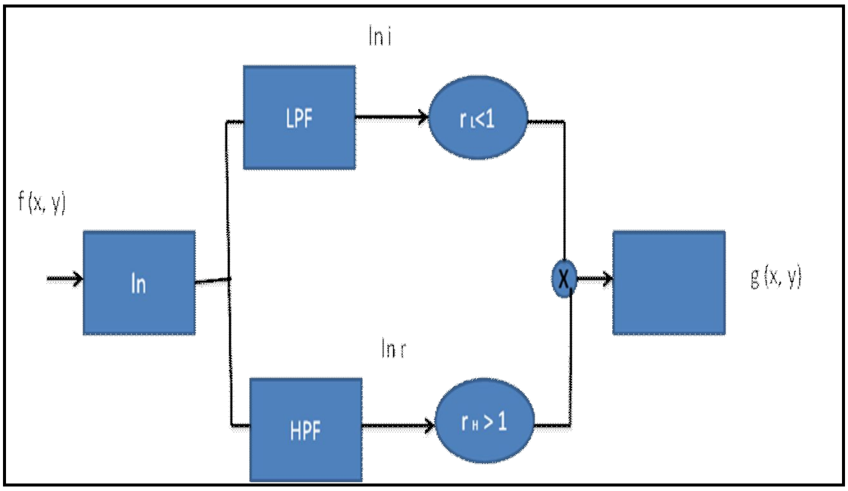

Fig. 2 Block diagram of homomorphic filtering

$r_L < 1$ To reduce the contribution made by low frequency(illumination)
$r_H < 1$ To increase the contribution made by high frequency (reflectance)
Net result: Dynamic range compression along with contrast enhancement

Material and Experimental:

Nonyloxy benzoic acid (9Oba) was procured from Sigma Aldrich laboratories. The citrate capped Gold nanoparticles are synthesized by following the established standard procedure reported in the literature. For uniform dispersion of nanoparticles in to 9Oba, the nanoparticles were first dissolved in ethyl alcohol, stirred well about 45 minutes and later introduced in the isotropic state of mesogenic material in the ratio of 70 µl concentration. After cooling the nano-doped nonyloxy benzoic acid (9Oba) was subjected to study of the textural and phase transition temperatures using a polarizing optical microscope with a hot stage in which the substance was filled in planar arrangement in 4 µm cells and these could be placed along with the thermometer described by Gray [16]. Textural and phase transition temperatures are studied after preparation of the sample and observations are made again to understand the stability of citrate capped Au nanoparticles.

Differential scanning calorimeter DSC (Perkin Elmer Diamond DSC) is used to obtain the transition temperatures and the enthalpy values. The image processing programme [17-19] of homomorphic filtering technique is coded in MATLAB tool for computational analysis of nano doped liquid crystalline textures. The transition temperatures along with the enthalpy values are given in Table 1**.**

Table 1: Phase variants, transition temperatures, Enthalpy values in 9Oba Pure and nano dispersed compounds

S. NO	Compound	DSC /POM	Scan Rate	Transition Temperatures °C				LC Thermal Range	
				I-N	N-SmC	SmC-SolidI	SolidI – Solid II	ΔN	ΔSmC
1	9Oba Pure	DSC	20c/min ΔHJ/g	132.52 14.34	115.38 4.57	89.35 30.78	64.98 58.15	17.14	26.03
		POM		132.9	116.0	91.0	63.0	16.9	25.0
2	9Oba +70ul of ct capped AU nano particles	DSC	20c/min ΔHJ/g	131.4	112.98 4.27	87.92 34.84	66.84 53.04	18.42	25.06
		POM		132.2	112.5	86.8	67.5	19.70	25.7

Results and Discussion:

The homomorphic filter approach for image processing is very well known as a way for image dynamic range and increasing contrast. According to this approach, input signal is assumed to consist of two multiplicative components: background and details. The standard problem in processing such signals involves logarithm operation, division on two components by implementing low-frequency and high-pass filters, addition of evaluations multiplied by different gain coefficients and exponent calculation. Fig. 3-10 show the collected images of 9Oba pure and with dispersed70µl citrate capped gold nanoparticles across I-N, N-SmC, SmC-Solid phases with digital camera connected to polarizing microscope with hot stage.

In terms of needed enhancement the most important features of this image are that it NTSC to equivalent true RGB color image, where NTSC is a standard color encoding scheme. Fig (c) in each case shows the contrast enhanced image by using the homomorphic filtering technique. From Fig (a) to (c) in all cases, we can observe the improvement in the appearance of the image with reduction of multiplicative noises like color dullness, darker portion and low contrast. The contrast enhanced image can be used to detect the phase perfectly in the liquid crystals, which is somewhat difficult with original image collected from the polarizing microscope connected with hot stage and camera.

9Oba Pure

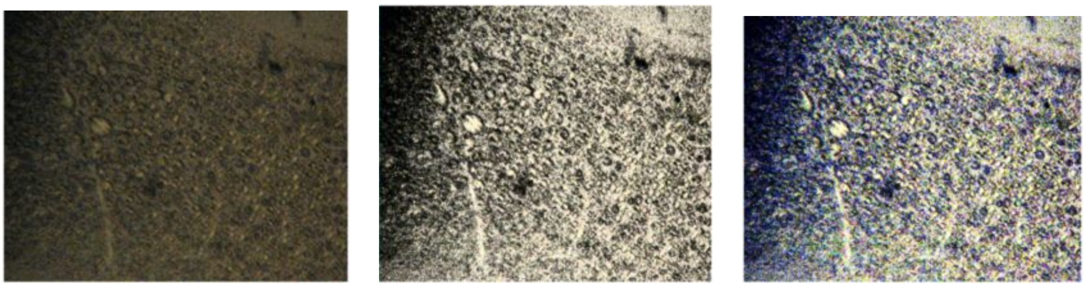

Fig. 3(a) **Fig. 3(b)** **Fig. 3(c)**

Fig. 3 I-N phase of 9Oba at 132.9 ^{0}C, 3(a) original image, 3(b) true RGB color image of original texture, 3(c) enhanced image from homomorphic filtering

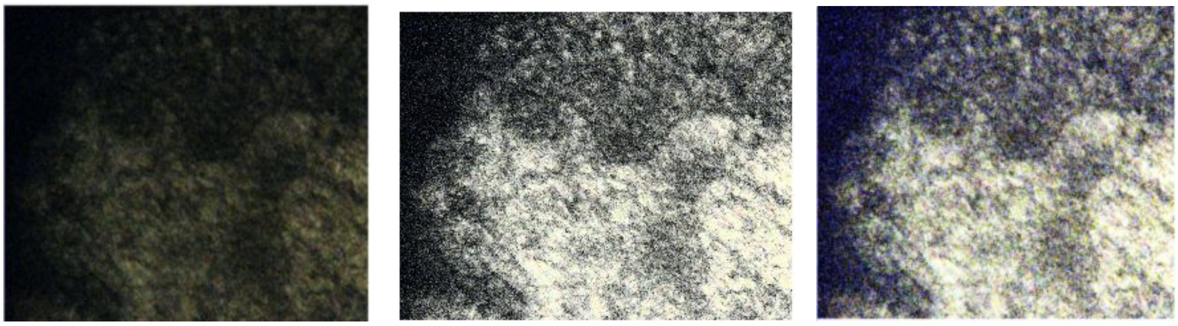

Fig. 4(a) Fig. 4(b) Fig. 4(c)

Fig. 4 Sc-Solid 1 phase of 9Oba at 91 ^{0}C, 4(a) original image, 4(b) true RGB color image of original texture, 4(c) enhanced image from homomorphic filtering

9Oba + 70µl of citrate capped Au nanoparticles

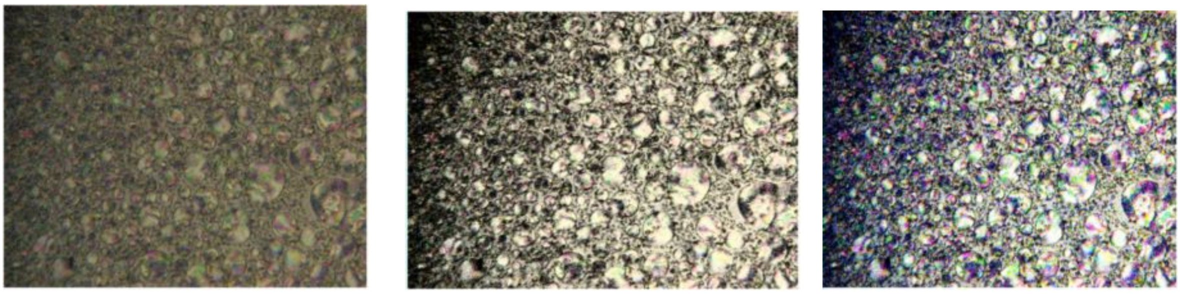

Fig. 5(a) Fig. 5(b) Fig. 5(c)

Fig. 5 Isotropic to Nematic droplets at 132.2 ^{0}C, 5(a) original image, 5(b) true RGB color image of original texture, 5(c) enhanced image from homomorphic filtering

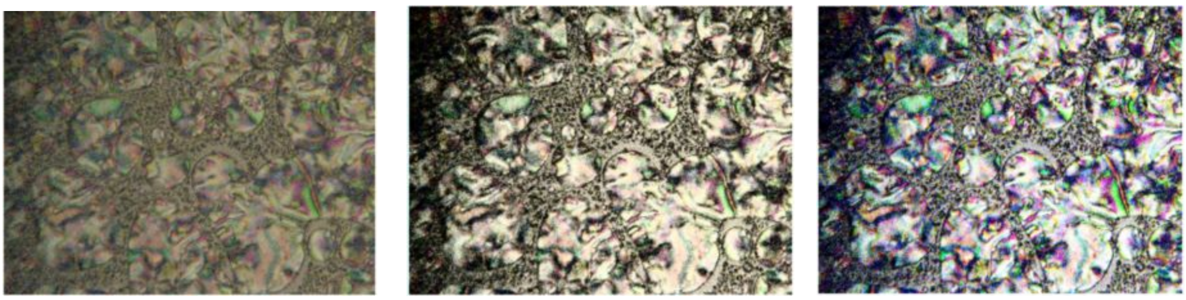

Fig. 6(a) Fig. 6(b) Fig. 6(c)

Fig. 6 Nematic phase at 131 ^{0}C, 6(a) original image, 6(b) true RGB color image of original texture, 6(c) enhanced image from homomorphic filtering

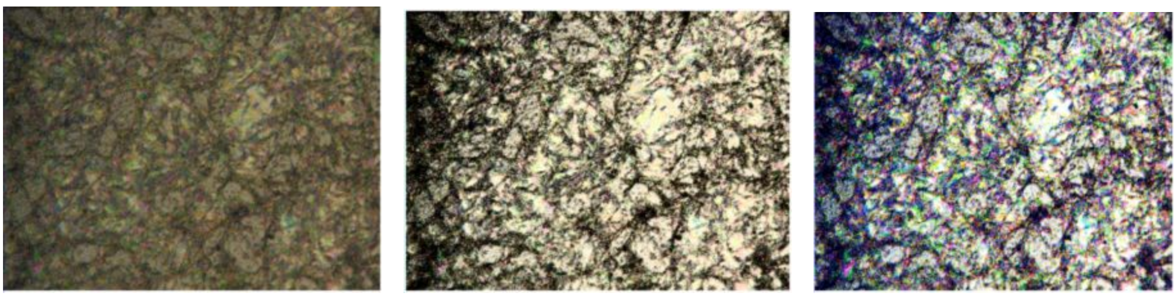

Fig. 7(a) Fig.7 (b) Fig.7(c)

Fig.7 Nematic phase to Sc transition at 112.5 ^{0}C, 7(a) Original image, 7(b) true RGB Color image of original texture, 7(c) enhanced image from homomarphic filtering

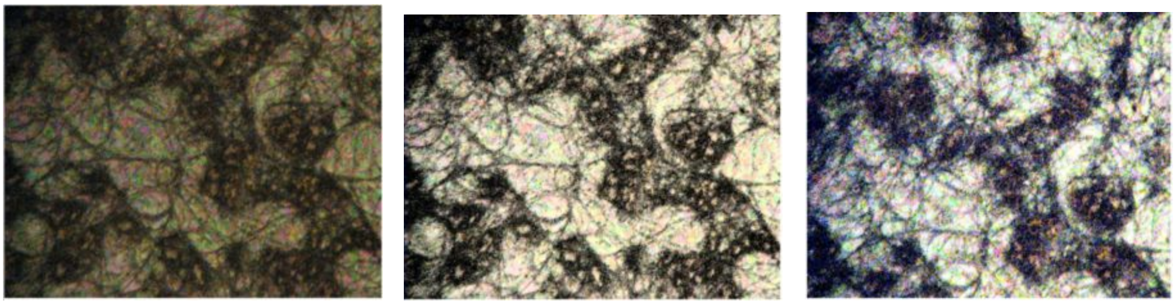

Fig. 8(a) Fig. 8 (b) Fig. 8(c)

Fig. 8 Smc to Solid 1 transition at 86.8 ^{o}C 8(a) Original image, 8(b) true RGB Color image of original texture, 8(c) enhanced image from homomarphic filtering

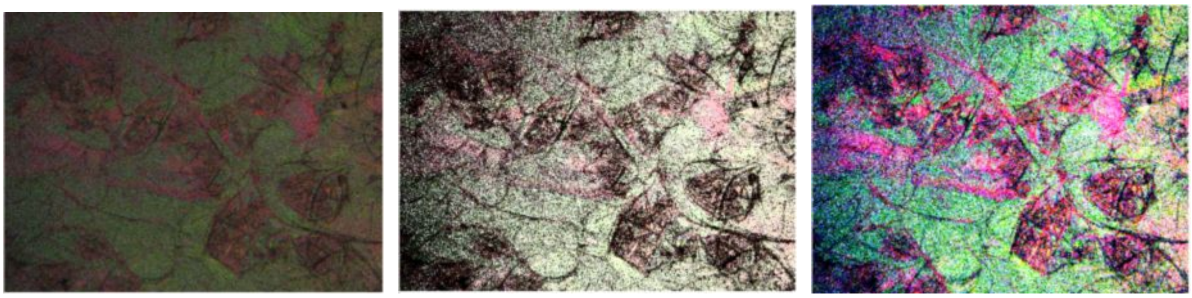

Fig. 9(a) Fig. 9 (b) Fig. 9(c)

Fig. 9 Smc to Solid 1 transition at 80.8 ^{o}C, 9(a) Original image, 9(b) true RGB Color image of original texture, 9(c) enhanced image from homomarphic filtering

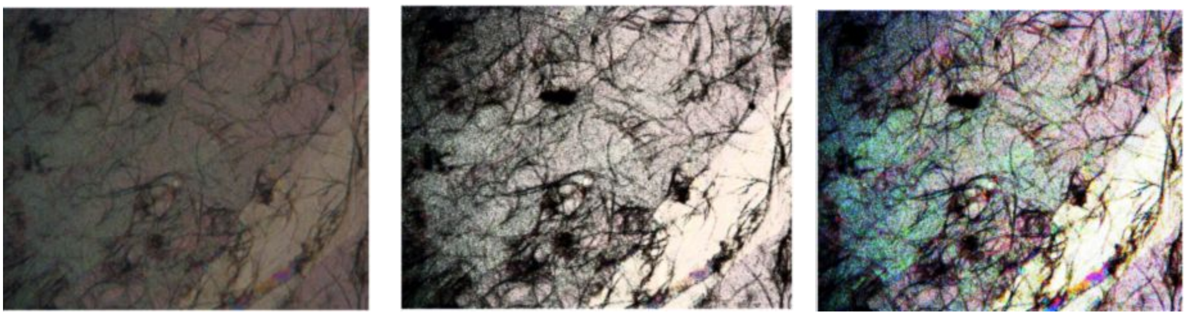

Fig. 10(a) Fig.10 (b) Fig.10(c)

Fig.10 Solid I to Solid II transition at 67.5^{o}C 10(a) Original image, 10(b) true RGB Color image of original texture, 10(c) enhanced image from homomarphic filtering

Conclusion:

In this paper homomorphic filtering technique is performed on the pure and with 70 µl citrate capped Au nanoparticles dispersed in 9Oba compound which produces textures for enhancing the contrasts in the image. By increased the visual appearance of the low contrast image with this current technique, the accurate identification of phases at transition temperatures is possible with naked eye. The obtained results of homomorphic filtering are giving the high contrast image which covers a broad range of the gray scale. The brightness is normalized across the image and enhanced the contrast in this technique. Further the transition temperatures obtained from polarizing microscope attached with the hot stage are in good agreement with those obtained from DSC. The slight differences can be attributed to the different experimental conditions. Moreover the nematic thermal range has been increased while dispersing the citrate capped gold nanoparticles in 9Oba.

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