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# Glare Reducing Windscreen Using Principle of Selective Reflection

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**ABSTRACT**:Automobiles are prone to accidents due to glare effect at night. The scope of this research is to reduce the glare. Theconcept of Electrochromic glass was used. A windscreen was made up of a pair of float glass enclosed with Twisted Nematic Liquid Crystals. The liquid crystal material exhibited a property of selective reflection of incident light. A liquid crystal material E48 was used for this purpose and the results were studied. The wavelength of light within a narrow range which caused glare was selectively reflected. This resulted in reduced intensity of glare thus protecting the driver from glare during night travel.

**KEYWORDS**:Glare, Windscreen, Liquid crystal cells, Twisted Nematic Crystals.

## I. INTRODUCTION

### 1.1 Measurement of glare

Glare is the temporary invisibility of eye caused by light of shorter wavelength. They can be classified in to two types namely, Disability glare and Discomfort glare. Disability glare is a rare case which causes permanent invisibility. Discomfort glare is a prevailing case which causes temporary invisibility of human eye due to shorter wavelength of light. It is one of the main causes for accident of vehicle in night.

Discomfort glare is measured using a system of scale called de Boer rating scale[1]. This scale have numerical values ranging from 1 to 9 is illustrated in Figure 1. From the past researches, it has been found that a light wavelength of 480nm[2] causes more discomfort.

1 Unbearable
2
3 Disturbing
4
5 Just Acceptable
6
7 Satisfactory
8
9 Just Noticeable

*Figure 1.de Boer rating Scale of glare*

### 1.2. Electrochromic glass

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In order to reduce the glare, the concept of Electrochromic glass can be used. Electrochromic glass has two layers of float glasses with a transparent film enclosed on their contact surfaces. The film is a transparent polymer dispersed liquid crystal (PDLC) film. The PDLC film contains liquid crystal ions like lithium (Li) which are oriented in a random pattern and scatter or reflect the incident light in the residual state. In this research, we pay attention to reduce the intensity of discomfort glare as much as possible.

## II. MATERIALS

Chiral molecules cause a twist in the nematic structure of liquid crystals. Such a helical phase is called a Cholesteric[3] liquid crystals or Twisted Nematic(TN) liquid crystals. Locally, the Cholesterics are very similar to the Nematicliquid crystals. They consist of quasi-nematic layers, whose individual directors are turned by a fixed angle on proceeding from one layer to the next. Usually, the layers are turned by an equivalent angle of $2\pi$ and the distance between these two layers defines the pitch 'p' of the helical structure. E48, a nematic liquid crystal material is used to make liquid crystal film. A pair of glass substrate is required to hold the liquid crystal film.

## III. PROPOSED TECHNIQUE

Lacker*et al.* (1990)[4] described the process of making a liquid crystal film. The same process was carried out to make substrate. Anematic liquid crystal material E48 (from Merck chemicals) was held between the pair of glass substrates. The nematic liquid crystal had the helical axis in the normal direction of the substrates and alsoan alignment structure in twist angle of $90^o$. This is known as planar structure[5]. This combination forms a TN liquid crystal film used in between the glass substrates.

At residual state, the incident light being polarized by an angle of $90^o$ is transmitted by the film.Goldfinger*et al.* (2010)proved that the liquid crystal material (E48) shows the property of selective reflection of wavelength corresponding to the pitch of the liquid crystal molecule. Since the light of wavelength 480nm caused more discomfort, this wavelength had to be reflected selectively. When the propagation direction of light was along the helical axis of the TN layer, the light ofwavelength corresponding to pitch 'p' of TN layer was reflected while other wavelengths passed through the substrate. The maximum wavelength ($\lambda_o$) of light which was reflected is governed by the equation,

$$\lambda_0 = n_a * p \quad \text{--- (I)}$$ [6]

where $\lambda_o$-maximum wavelength of light reflected

$n_a$-average of refractive indices of liquid crystal material

p - pitch of the liquid crystal material

$$n_a = (n_0 + n_e) / 2 \quad \text{--- (II)}$$ [6]

where $n_a$- average of refractive indices of liquid crystal material

$n_o$ - ordinary refractive index of liquid crystal material

$n_e$- extra-ordinary refractive index of liquid crystal material

$$\Delta\lambda = \lambda_o * \Delta n / n_a \quad \text{---- (III)}$$ [6]

where $\Delta\lambda$ - bandwidth of reflected wavelength of light

$\lambda_o$-maximum wavelength of light reflected

$\Delta n$ – birefringence of liquid crystal material ($n_e – n_o$)

$n_a$-average of refractive indices of liquid crystal material

## IV. CALCULATIONS

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**Vol. 3, Issue 10, October 2014**

**4.1.During Summer (assume $T = 40^0C$ )**

The ordinary and extra-ordinary refractive indices of E48[7] at $40^0$c for $\lambda_o$ =486nm are 1.5337 and 1.7649 respectively.

$$n_a = (n_0 + n_e) / 2$$

$$= (1.5337+1.7649)/2$$

$$n_a = 1.6493$$

Now, substituting the values of $\lambda_o$ and $n_a$ in equation (I),

$$480 = 1.6493 * p$$

$$p = 291nm$$

Light of wavelength matching this pitch was reflected from the film and hence it did not pass through the layer.

At the wavelength of $\lambda_o$, the TN layer exhibits 50% reflectance and 50% transmittance. The bandwidth of the reflected wavelength $\lambda_o$ is centered in the range of $\Delta\lambda$ which is given by equation (III),

$$\Delta\lambda = \lambda_o * \Delta n / n_a$$

$$= 480 * 0.2312 / 1.6493$$

$$\Delta\lambda = 67.28nm$$

Maximum wavelength reflected = 480 + 33.6 = 513.6nm
Minimum wavelength reflected = 480 – 33.6 = 446.4nm

**4.2. During Winter ( assume $T = 15^0 C$ )**

The ordinary and extra-ordinary refractive indices of E48[7] at $15^0$c for $\lambda_o$ =486nm are 1.5366 and 1.7969 respectively.

$$n_a = (n_0 + n_e) /2$$

$$= (1.5366+1.7969)/2$$

$$n_a = 1.6667$$

Now, substituting the values of $\lambda_o$ and $n_a$ in equation (I),

$$480 = 1.6667 * p$$

$$p = 288nm$$

The bandwidth of the reflected wavelength $\lambda_o$ is centered in the range of $\Delta\lambda$ which is given byequation (III),

$$\Delta\lambda = \lambda_o * \Delta n / n_a$$
$$= 480 * 0.2603 / 1.6667$$

$$\Delta\lambda = 74.96nm$$

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Maximum wavelength reflected = 480 + 37.5 = 517.5nm
Minimum wavelength reflected = 480 – 37.5 = 442.5nm

## V. RESULTS AND DISCUSSIONS

*Table 1. Wavelength of light reflected at different temperatures*

| S.No | Season | Wavelength to be reflected (nm) | Minimum wavelength reflected (nm) | Maximum wavelength reflected (nm) |
|---|---|---|---|---|
| 1. | Summer (T= $40^oC$) | 480 | 446.4 | 513.6 |
| 2. | Winter (T=$15^oC$) | | 442.5 | 517.5 |

The above calculations show that the wavelengths which were reflected were in the range of 517.5nm to 442.5nm. Thus, the wavelength causing discomfort glare has been partially reflected resulting in reduced intensity of glare. Thus, the use of TN liquid crystal film (like E48) in between a pair of electrochromic glass windscreen reduces the intensity of glare by reflecting the glare causing wavelength of light (480nm). This gives driver, safety and comfort while driving a vehicle at night.

The light of wavelength 480nm corresponds to blue light. One can detect this blue light since it is partially reflected and partially absorbed. Thus, the remaining quantity of blue light is visible on the other side. Further, the results are confined only to tropical regions. Development of new liquid crystal material which exhibit selective reflection properties in even more lower temperature may lead to extension of this windscreen to automobiles of all regions of various temperatures.

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