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Nonlinear optical reorientation behavior in hybrid-aligned dye-doped liquid crystals

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Nonlinear optics of liquid crystals (LCs) has been extensively studied, aiming to develop all-optical system in the future. The key is to make LC devices work with very low light power, such as a hand-held laser pointer. In 1990, it was reported that the nonlinearity of LCs can be significantly enhanced by doping a small amount of dye.[1] Since then a great deal of interest was devoted to further improve the optical response in dye-doped LCs. So far most efforts have been focused on chemical structure modification. For instance, Zhang et al., found that oligohiophene (TR5) could serve as an effective dye molecule for dye-induced nonlinear enhancement.[2] On the other hand, a highly efficient nonlinear optical response in terms of both low threshold intensity and high stability was achieved by our group in TR5-doped LC through polymer stabilization.[3] However, large light power requirement compared to that of photochemical process is still a big challenge. Recently, hybrid-aligned LCs in which molecules show homeotropic alignment at one surface and homogeneous alignment at the other, Figure 1a, has received substantial attention due to its unique properties.[4] This provides us a promising way to further reduce the threshold intensity for nonlinear optical reorientation. In this study, hybrid-aligned TR5-doped LC was designed and its nonlinear optical reorientation behavior was evaluated, aiming to further reduce the threshold intensity.

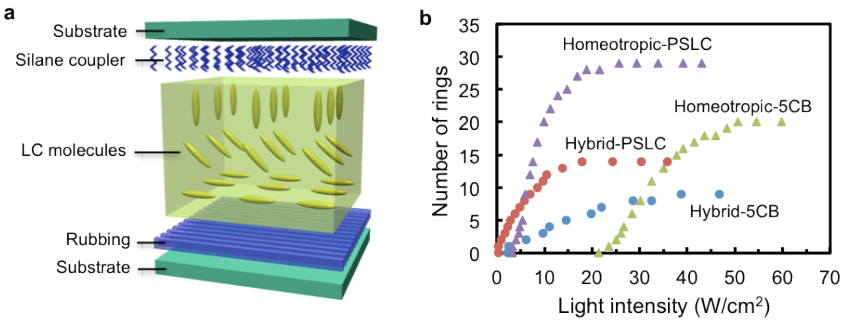

Figure 1. (a) Geometry of hybrid-aligned LC cell. (b) Number of diffraction rings as a function of light intensity for hybrid-5CB, hybrid-PSLC, hometropic-5CB and homeotropic-PSLC.

Both hybrid-aligned TR5-doped low-molecular-weight LC (5CB) and hybrid-aligned TR5-doped polymer-stabilized LC (PSLC) were successfully fabricated. Nonlinear optical reorientation behaviors were carefully evaluated by self-diffraction ring measurement. At the same time, conventional homeotropic-aligned cells were also prepared as comparisons. Results indicated that hybrid alignment was very efficient for reduction of nonlinear optical threshold intensity (Figure 1b, by a factor of 9.4 for low-molecular-weight system and 8.5 for polymer-stabilized system) as well as for acceleration of optical response (by a factor of 10 for both systems). We believe that the results of the current study have brought us one more step closer to manipulating LC alignment with a low light power, leading to a new direction of material design from the aspect of molecular arrangement.

References:

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