Study on the Carbon Emission Reduction in Polarizers for Achieving Carbon Neutrality

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Abstract

Recent environmental issues are a serious challenge faced by all of humanity, and various measures such as regulations and usage restrictions are being explored to address them. This trend is no exception in the display industry, and this paper presents research findings on eco-friendly polarizers aimed at reducing carbon dioxide emissions.

To reduce carbon dioxide emissions, approaches such as replacing traditional petroleum-based film materials with plant-derived substances or recycling discarded plastic resources for reuse were adopted. Additionally, material design was implemented to reduce electricity consumption during component production and processing. As a result, we propose an eco-friendly polarizer technology that achieves reduced carbon dioxide emissions compared to conventional polarizers.

Author Keywords

Eco Friendly Polarizer; Bio or Recycled based Film; Reduction Carbon Emission.

1. Introduction

With carbon neutrality by 2050 emerging as a global agenda, all industries are being called upon to undergo gradual and fundamental transformations to achieve this goal [1], [2], [3]. In response, companies are actively utilizing renewable energy in manufacturing processes and optimizing production methods to reduce carbon emissions during the production phase.

On the product side, companies are developing low-power consumption products that help consumers reduce electricity usage during operation, thereby contributing to lower carbon emissions. Additionally, they are focusing on incorporating low-carbon materials into product components. These materials include recycled resources, which are made by reprocessing post-consumer waste, and bio-based materials derived from plant sources.

Recent exhibitions on display products and materials have highlighted this trend, with numerous companies showcasing environmentally friendly products and materials. These efforts reflect the growing importance of sustainable practices in product development.

Conventional polarizers are primarily manufactured from petroleum-based materials, which generate carbon emissions throughout their lifecycle—from oil extraction to production and disposal.

This study examines methods to reduce carbon emissions in polarizer components used in display devices.

In this research, petroleum-based films were replaced with bio-based materials and recycled resource-based films. Additionally, material designs that reduce energy consumption during production were implemented, demonstrating the potential to significantly reduce carbon emissions.

2. Results and Discussion

As previously mentioned, a polarizer is an optical film with a complex multilayer structure composed of various films. One of its key characteristics is that its detailed components can vary depending on the product and model.

Table 1. The basic structure and constituent materials of an LCD polarizer.

Content	Layer	Material	Thickness
(a)	Protect film	PET / Acrylate	~55 μm
(b)	Surface coating	Acrylate	~5 μm
(c)	Film substrate	TAC/PET/Acryl	20~80 μm
(d)	Layer adhesive	Acrylate	~1 μm
(e)	PVA film	PVOH	~30 μm
(f)	Layer adhesive	Acrylate	~1 μm
(g)	Film substrate	TAC/PET/Acryl	20~80 μm
(h)	Pressure sensitive adhesive	Acrylate	~30 μm

Table 1. shows the basic structure of a polarizer applied to an LCD. The functions of its components are as follows: Table 1.(a): This is a protective film that serves to shield the polarizer from external damage during handling. Table 1.(b): This is a surface coating layer, added after the protective film is removed, to enhance resistance to external impacts during use and to improve image quality. Table 1.(c): This layer consists of a base film, which functions to prevent deformation (shrinkage) of the polarizer film. Table 1.(e): The PVA layer is treated with iodine staining and stretching to provide linearly polarized light functionality. Table 1.(g): This layer is constructed for the same purpose as Table 1.(c). Table 1.(h): This is an adhesive layer that allows the polarizer to be attached to the device module.

This forms the basic structure of a polarizer. The materials used in polarizers can be broadly categorized into film types and coating materials. The films are manufactured using resins, which serve as the fundamental material, through extrusion or solvent casting methods. The resins mentioned above are primarily derived from petroleum-based sources, and the organic solvents used in film production are also generally petroleum-derived.

In addition to film types, other layers such as surface coatings and PSA (Pressure Sensitive Adhesive) materials are processed to meet performance requirements using acrylate-based curable materials and organic compound-based solvents as raw materials. Given the carbon emissions generated during the production of petroleum-based components, a certain level of emissions is considered inevitable. In the past, there was a lack of awareness regarding such

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emissions, so they were not seen as a significant issue. However, with the growing focus on environmental sustainability and sustainable development in recent years, minimizing these emissions has become increasingly emphasized.

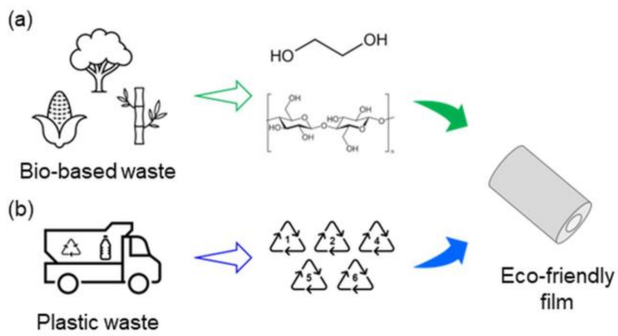

Figure 1. (a) Methods for applying bio-based materials(corn cob, sugarcane bagasse). (b) Methods for applying recycled materials. (c) Application of eco-friendly materials in optical film.

This study examines solutions to mitigate environmental issues caused by unavoidable carbon emissions during the production of products and components. Based on the findings, the study aims to propose sustainable directions for the display industry. By narrowing the focus to polarizer components, two specific strategies for reducing carbon emissions are presented.

The first strategy involves replacing conventional petroleum-based raw materials with low-carbon alternatives. Specifically, this entails substituting petroleum-derived materials with plant-based raw materials and reprocessing or recycling post-consumer waste to replace existing materials. Petroleum-based materials release stored carbon from the ground into the atmosphere, resulting in a net increase in carbon emissions. In contrast, bio-based materials, derived from plants or microorganisms, absorb carbon dioxide through photosynthesis during their growth. Even after these materials are used and decomposed, the carbon dioxide released can be reabsorbed within the natural carbon cycle, achieving a near-carbon-neutral effect [4].

Additionally, utilizing recycled materials ensures that resources are reused within a closed-loop system, thereby reducing unnecessary resource waste and minimizing carbon dioxide emissions from resource combustion. These approaches offer practical solutions for reducing carbon emissions and enhancing sustainability in the display industry.

As the first implementation strategy, this study focuses on developing and applying plant-based and recycled materials as alternatives to petroleum-based raw materials in the production of films used in polarizers. The target film types include PET (Polyethylene Terephthalate), PMMA (Polymethyl Methacrylate), and TAC (Cellulose Triacetate). The plant-based raw materials are derived from sustainable resources such as sugarcane, corn, and wood, providing an eco-friendly solution to reduce carbon emissions [5].

Additionally, a portion of the films was replaced with recycled materials to enhance sustainability. The recycled materials were obtained from post-consumer plastic waste, which was processed through mechanical and chemical recycling to serve as part of the film resin composition. Performance evaluations confirmed that films containing recycled materials maintained the same functional properties as those made from conventional raw materials [6].

This study demonstrates the feasibility of integrating plant-based and recycled materials into polarizer films without compromising performance, thereby contributing to the advancement of sustainable display technologies.

The second approach involves reducing the resources required during component manufacturing. These resources include materials directly or indirectly used in the production of polarizers, as well as the electricity consumed during the manufacturing process. The production of polarizers involves the extensive use of various types of organic solvents, most of which are petroleum-based materials. Reducing the usage of these solvents plays a critical role in lowering carbon emissions.

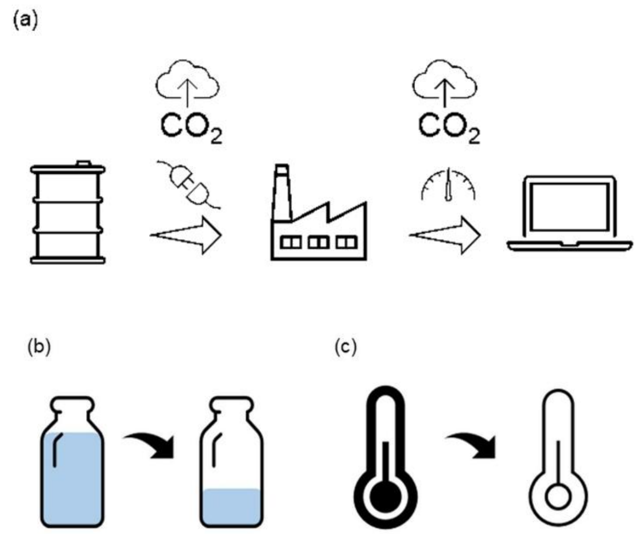

Figure 2. (a) The general production process of industrial products. (b) Reduction of petroleum-based solvent usage to lower CO_2 emissions. (c) Transition to low boiling point solvents to reduce CO_2 emissions.

In this study, the amount of organic solvents used in polarizer production was reduced by approximately 50% compared to conventional methods, and lower-boiling-point organic solvents were introduced as replacements and applied to material development. The selection of low-boiling-point organic solvents was aimed at reducing the electricity consumption required to evaporate the solvents during the drying process in polarizer production. Currently, most electricity is generated using fossil fuels such as coal, natural gas, and oil, a process directly linked to carbon emissions.

Therefore, by reducing the use of petroleum-based organic solvents and introducing low-boiling-point solvents, we were able to achieve significant reductions in the electricity required for polarizer production and, consequently, a groundbreaking decrease in the total carbon emissions during the manufacturing process.

As a result of implementing the two carbon emission reduction strategies, the proportion of eco-friendly materials used in polarizers increased significantly, reaching approximately 50%.

This represents a substantial positive impact on reducing carbon emissions. It is important to note that recycled materials cannot be identified through physical or chemical analysis alone, and third-party external certification is required to verify their recycled origin. By utilizing certified materials and systematically managing production processes, the eco-friendliness of the manufacturing process can be officially validated.

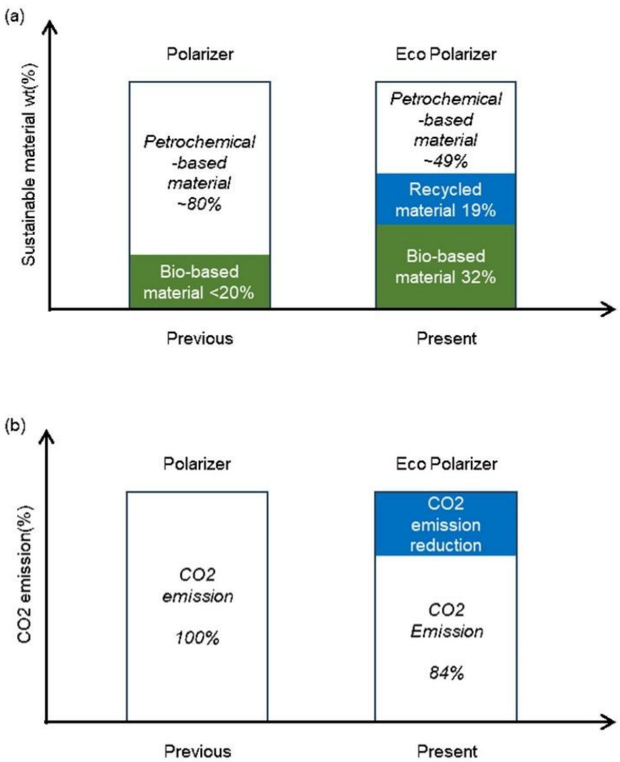

Figure 3. (a) The usage rate of eco-friendly materials in the developed polarizer. (b) Estimated CO_2 emissions generated during the manufacturing process of the developed polarizer. (c) Estimated CO_2 emissions generated during the manufacturing process of the developed polarizer

Additionally, polarizers incorporating eco-friendly materials and reduced usage of organic solvents and electricity demonstrated approximately 16% lower carbon emissions compared to conventional structures. This outcome was calculated using data from Korea LCI (Life Cycle Inventory) DB, Gabi (Sphera), and Ecoinvent [7], [8].

Furthermore, it was confirmed that polarizers developed using strategies of eco-friendly material substitution (replacement) and resource reduction (reduce) maintained performance levels equivalent to those of conventional products. The eco-friendliness of these components was also officially verified by external certification bodies.

Figure 4. (a) an external certification related to the Bio based material usage rate of the developed polarizer. (b) an external certification related to the reduction of CO_2 emission in our products applying the developed polarizer.

3. Conclusion

I We are faced with the critical challenge of achieving carbon neutrality to build a sustainable global environment. To realize this goal, it is essential to move beyond traditional practices and apply 3R technologies (Reduce, Reuse, Replace) more thoroughly across various industrial sectors [9]. This study focuses on the strategies of replacement and reduction within 3R technologies, conducting an in-depth analysis of their effectiveness in achieving carbon neutrality. Based on these findings, we aim to present a clear developmental direction not only for eco-friendly product development but also for fostering a sustainable global environment.

4. References

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