Research and Application Progress of Photochromic Materials

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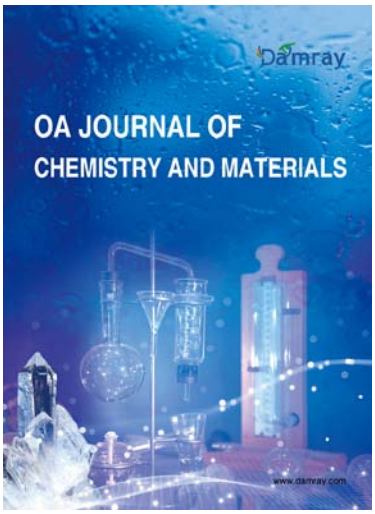

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Abstract

In this paper, by discussing the research and application progress of photochromic materials, we can clearly and intuitively understand that the current high-tech research fields in our country focus on the research of photochromic materials. It is said that photochromism is some chemical reaction produced by the material when it is irradiated by light. Under the irradiation of light, it can present colorful color-changing materials. It has a history of 150 years. For photochromic materials, the research is of great significance, and its development has more promising prospects. Based on this, this paper focuses on thinking and exploration from the research and application progress of photochromic materials, and puts forward corresponding suggestions, which are willing to share with you.

Keywords

Color-changing material, Research, Application progress

1. Research on different types of photochromic materials

1.1 Organic photochromic materials

Organic photochromic materials have the advantages of high modification, rich color and fast light response, and most of them can be activated under ultraviolet light of 200~400nm. For some organic matter, the range can be extended to 430nm, but visible light can activate very little organic matter. The e mechanisms of color change mainly include double bond breaking and combination (homolytic bond, bond splitting), isomer formation (proton transfer tautomerization, cis-trans isomerization), acid-induced discoloration, cyclic reaction, REDOX reaction, etc. There are many types of organic photochromic materials which can be modified for different research purposes by introducing

specific functional groups. At present, most studies are focused on diarylethylene, captive spermatic anhydride, spiropyran, spioxazine, azobenzene, schiff base. Diarylvinyl and carbonic anhydride derivatives show irreversible photochromic properties and can be used in optical memory, open optical switching device and display. The isomers of spiropyran, naphthiopran, spirooxazine and azobenzene produced by light exhibit thermodynamic instability. For the types of use, the following descriptions of diarylvinyl and spiropyran organic photochromic materials are given.

1.2 Diarylethenes

Two different forms of ring opening and ring closure are produced by cyclic reactions of diarylethenes. The schematic diagram is shown in Figure 1. These two forms can be converted into each other under the action of light of different wavelengths. The physical and chemical properties of the absorption spectrum, refractive index, dielectric constant, redox, etc., also change during the transformation. Compared with other photochromic materials, it has the characteristics of good thermal stability, fatigue resistance, large chemical reaction spectrum, high photosensitivity, and fast chemical reaction speed. The research on diaryl ethers began in 1988, when the Japanese scientist M. Irie designed and synthesized diarylethene molecules for the first time based on the photochromic compound stilbene. Among them, there are many studies on diarylethene molecular fluorescence switches that realize the optical information storage of molecular information. For example, Xuedong Liu et al. Qi Guosheng et al. Xu Haibing et al systematically introduced the related research on diarylethenes as molecular switches.

1.3 Spiropyrans

Spiropyrans are one of the earliest and widely studied organic photochromic materials. It achieves discoloration through "open-loop colorization, closed-loop color loss". The C-O bond in the colorless spiropyran structure was broken and opened under UV light irradiation. Molecules rotate locally and form coplanar fluorescent structures with enamel to generate color, and under the action of visible light or heat, the open ring can revert to the original helical ring structure. Spiropyrans have good photochromic properties but poor fatigue resistance.

Recently, studies have been carried out to combine Spiropyran with macromolecules to prepare unity-responsive polymers containing spiropyran. Keum et al. showed that the polymer retained photochromic properties consistent with its monomer. Photosensitive microgel has an excellent application prospect in the field of intelligent drug transportation and controlled release.

2. Inorganic photochromic materials

Inorganic photochromic materials mainly include rare earth complexes, transition metal oxides, polyoxometalates and metal halides. Compared with organic photochromic materials, inorganic photochromic materials are less in number and develop more slowly, but they have many characteristics superior to organic photochromic materials. For example, the color change rate is fast, the color change duration is long, the thermal stability is high, the fatigue resistance is good, the mechanical strength is high, the macro control, the easy molding and so on. It can be used in information storage, intelligent Windows, sunglasses, sensors, intelligent switches, defense and many other fields. Photochromism of inorganic materials is mainly achieved through ion and electron double injection extraction, electron transition and electron transfer in lattice. Most can be induced by ultraviolet light, and some inorganic photochromic materials can also be activated by other wavelengths of light.

The research of inorganic photochromic materials mainly focuses on inorganic photochromic glass materials and inorganic photochromic crystal materials. However, there are few researches on inorganic powder photochromic materials, and most of them only focus on the general characterization and description of color changing properties. The lack of in-depth understanding of the mechanism of color change is a major problem in the subsequent development of new high-quality inorganic photochromic materials.

3. The application of photochromic materials

Photochromic materials are widely used in various fields such as optical information storage, anti-counterfeiting, decoration and protection, and fluorescent switches due to their special physical and chemical properties.

3.1 Optical storage of information

Using the reversible color-change properties of photochromic materials, the two stable states before and after the color change correspond to 0 and 1 in binary, respectively. Thereby, a rewritable information storage element can be prepared, and the element has the advantages of fast reading, writing, fast rubbing and high storage density. Studies

have shown that diaryl groups, fulgides and azo dyes in organic photochromic materials can be used in the field of information storage. Among them, carboplatinic acid has become one of the research hotspots of optical information storage materials due to its high fatigue resistance and good thermal stability. Diaromatic hydrocarbons have good thermal stability, sensitivity to visible light, large chemical reaction spectrum and fast chemical reaction rate. After 50 low-speed readings, the recorded information maintained high contrast [9]. For azos, it has a significant light polarizing effect, and using polarized light beams, information can be written, read, erased and rewritten by birefringence. It is a promising optical recording medium.

3.2 Anti-counterfeiting application

In the early days, the purpose of anti-counterfeiting was mainly achieved through the independent action of photochromic materials, such as making anti-counterfeiting ink or anti-counterfeiting paper. Later, in order to further improve the resistance of anti-counterfeiting materials and avoid being imitated and failing to achieve the purpose of anti-counterfeiting, the anti-counterfeiting method of photochromic materials is gradually formed by combining with other anti-counterfeiting methods, and the performance of anti-counterfeiting technology has been improved.

3.3 Decoration and protection

Apply photochromic materials in everyday life to provide decorative or protective effects. For example, add it to clothing or architectural paint to make color changes according to clothing or building walls to enhance beauty and bring joy to people's lives. It also effectively improves the market competitiveness of products. Adding photochromic substances to the spectacle lenses intelligently adjusts the photosensitivity of the materials and causes the color changes of the glasses under strong light irradiation, which can avoid direct damage to the eyes. The current photochromic glasses technology is quite mature. In addition, smart windows (photochromic glass) can intelligently change color according to the intensity of incoming light. In turn, regulating light transmittance and carrying heat, it plays the role of regulating indoor light and saving energy.

Conclusion

Photochromic materials have good applications in biological sample detection, photocontrolled supramolecular materials, dye industry, visual detection, molecular catalysts, bioactive photoregulation and many other fields.

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