EXPLORING THE APPLICATION OF LONG PERSISTENCE LUMINESCENT MATERIALS IN STREET FURNITURE DESIGN

Hong Yang SONG, Xu CHEN, Liang YU and Kin Wai Michael SIU
School of Design, The Hong Kong Polytechnic University, Hunghom, Hong Kong

Introduction

The application of long persistence luminescent materials in the street furniture design has attracted a great many research interests, for the reasons including easy recyclability and processability, great energy saving, and aesthetic function as well. However, a comprehensive study on a combination of luminescent and other suitable materials (e.g., ceramic, polymer) is needed before the application in the street furniture is achieved.

By reviewing the current application of long persistence luminescent materials in the street furniture design, moreover, reviewing the background and fabrication methods of the materials, a gap of the application in the street furniture design, and then a further study direction for exploring applicability of the materials in street furniture design are suggested.

Background of Luminous Materials

Long persistence luminescent materials are typically known as “noctilucent powders”, which can absorb a visible light energy and then emit the energy also in the form of visible light. They have not been widely explored in the application of the street furniture design, except for some danger signs and functional road-blocks.

Traditional long persistence luminlescent materials such as Zinc sulfide and Calcium sulfide were short in the length of glowing time period. The advent of the radioactive materials such as Co and Pm improved luminescent properties in terms of both time length and glowing intensity, however with limited success regarding to the harmfulness to the human health and environment. In 1990s, a series of long persistence luminescent materials of high-efficiency and non-radioactivity emerged, such as lanthanum. At the same time, various basic matrix materials such as non-metal sulfide, alumninate and sulfide were developed successively [1].

In the late 20th century, products made of rare earth long persistence luminescent materials were comprehensively adopted in the economic developed countries in the field of army, industry transportation, for example, famous Sydney Opera House, Germany’s Frankfurt Airport, France Charles de Gaulle Airport, Dentsche Centre Building, European Airbus, Boeing and McDonnell-Douglas Aircraft, Britain-London Subway, Japanese-Tokyo Subway and Vessels recognized by Norway vessel’s House, all of which adopted long persistence luminescent material in the safety signs and some other furniture successively.

Fabrication Methods

The fabrication methods of the long persistence luminescent materials have greatly developed since their discovery in the 20th century, which are categorized below in Table 1.

Table 1. A summary of different fabrication methods for long persistence luminescent materials

Fabrication method	Main technique	Characteristics
High-temperature reaction	calcination at high temperature	Simple technique, few by-products, low cost; coarse grain [2]
Combustion method	oxidation-reduction reaction	simple equipment, reaction and energy saving; environmental pollution [3]
Sol-gel method	hydrolysis and alcoholysis reaction	fine grain (nano-scale) [4]
Microwave synthesis	microwave irradiation	time and energy saving [5]

Glowing Mechanism and performance affecting factors

The light emitting process is divided into the following procedures: (1) the host lattice absorbs excitation energy; (2) the host lattice transfers the excitation energy to the ion, and makes it excite; (3) the ion being excited gives out light and returns to ground-state.

Currently, the long persistence luminescent matrixes being widely used are aluminate, sulfide and silicate. Take the night sign application as a consideration, the glowing time should be more than 1000 minutes and the color should be mainly green.

The introduction of the activator and fusion agent greatly influences the luminescent material performance. The properties of the long persistence luminescent materials are summarized in Table 2 below.

Table 2. A summary of properties of various long persistence luminescent materials

Composition	Color	Wave legth (nm)	Intensity after (min)		Glowing time (min)
			10	60	
ZnS:Cu	yellow-green	530	45	2	about 200
$BaAl_2O_4$:Eu,Dy	yellow-green	496	-	-	about 120
$CaAl_3O_4$:Eu,Nd	purple-blue	446	20	6	about 1000
$Sr_4Al_{14}O_{25}$: Eu,Dy	blue-green	490	350	50	>2000
ZnS:Cu, Co	yellow-green	530	40	5	about 500
$SrAl_2O_4$: Eu,Dy	yellow-green	520	400	60	>2000
CaSrS:Bi	blue	450	5	0.7	about 90
CaS: Eu,Tm	red	650	1.2	-	about 45

The activator is a major factor influencing the intensity and time length of glowing. For aluminate luminescent materials, the activators adopted are usually Sm^{3+}, Tb^{3+}, Eu^{2+}, Ce^{3+}, Mn^{2+}, Bi^{3+}[6], which make the glowing time length much longer. For the sulfide luminescent material, associating with problems including unstable chemical nature, harmful radiation, the transition metal ions such as Mn^{2+}、Cu^{3+} have been acted as the activation center successively. Various luminescent matrix materials mixing with Mn^{2+} were reported to be fabricated successfully [7] including $CaAl_2O_4$: Mn^{2+}, Ce^{3+}; $Ca_2Al_2SiO_7$: Mn^{2+}, Ce^{3+};Mg SiO_3: Mn^{2+}, Eu^{2+}, Dy^{3+}, and produced green, yellow and red glowing light with a time length of 10, 10 and 4 hours respectively. The mechanism can be explained by the energy transformation to Mn^{2+} from the activated rare earth after being shined on.

The frequently adopted fusion agents are B_2O_3, H_3BO_3 and etc, which can help accelerate the melting process of the high melting temperature luminescent materials, and then obtain the red glowing product. Nag Abant [8] found out that B_2O_3 played an important role in the process of stabilizing phases in the long persistence luminescent material, the same effect of which can also be achieved by urea and camphor. Searching for new multi-functional fusion agents is a promising direction to develop new luminescent materials.

Outlook

To sum up, on one hand, rare earth ions activated aluminates and sulfide have become the main subjects of long persistence luminescent materials, with high aging resistance, fire retardance, high intensity and long glowing time in the applications such as night and security signs. They have represented one of the developing directions.

On the other hand, as far as the application concerns, that the monotonic glowing color (mainly blue, blue green, yellow, but still being short of the long-wave band orange and red), and also the poor water resistance has restricted the development to a certain extent. However, coating treatment on the surface can be carried out to improve the water resistance. A promising way to solve these problems may be based on the modification of the matrix and activator. It is believed that a series of brand new activators and fusion agents will be available to substitute the rare earth materials, with well control over the fabrication process, compositions and structures of the end products, as well as the glowing intensity, time length, colors and stability, environmental favorability, leading to a wider application in the street furniture design.

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