Jurnal Kejuruteraan SI 4(2) 2021: 17-21
https://doi.org/10.17576/jkukm-2021-si4(2)-03

Strontium Aluminate Compound as Road Line Materials Application
(Penggunaan Strontium Aluminate Compound sebagai Bahan Jalur Jalan)

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Received 13 March 2021, Received in revised form 10 May 2021
Accepted 30 September 2021, Available online 31 October 2021

ABSTRACT

Road line marking are used as a mean of controlling traffic and road user safety. It is very significant on any roads and intersections as they promote road safety. They highlight a harmonious flow of traffic along guided paths of travel. The objectives of this study are to investigate the properties of road line materials and examine the illuminance properties of glow in the dark powder applied in road marking materials. The use of photoluminescent glow-in-the-dark material was tested in the lab for its suitability (luminosity and the glow duration). The methods involved are selection of suitable type of glow in the dark materials, selection of optimum mixing ratio of the glow in the dark powder with thermoplastic powder, and finally analyzed for the properties of the type of the material chosen. The fine granular strontium aluminate compound, SrAl2O4 was selected as the most suitable type of glow in the dark material. Based on the laboratory analysis, the optimum ratio of the glow in the dark material to be used with thermoplastic powder is 55% of total mix volume. The average visible light emission period is in acceptable range of 20 m. This is a suitable distance to implement the road line because of the high visibility on the road during dark or night.

Keywords: Road line; photoluminescent; luminosity; glow in the dark; thermoplastic

ABSTRAK

Penandaan garisan jalan adalah penting untuk mengawal lalu lintas dan keselamatan pengguna jalan raya. Ia amat berkesan apabila digunakan di sepanjang jalan dan persimpangan kerana ianya dapat meningkatkan keselamatan jalan raya. Ia berfungsi untuk mengawal aliran lalu lintas kenderaan di sepanjang jalan secara harmoni. Objektif kajian ini adalah untuk mengkaji sifat pencahayaan serbuk bersinar dalam kegelapan yang akan digunakan sebagai bahan tambah untuk cat garisan jalan. Penggunaan serbuk bersinar dalam kegelapan telah diuji di dalam makmal untuk mengkaji kesesuaian penambahan bahan ini (kecerahan dan tempoh bersinar) ke dalam cat garisan jalan. Kaedah yang diaplikasikan dalam kajian ini termasuk pemilihan serbuk bersinar dalam kegelapan yang bersesuaian, pemilihan nisbah pencampuran bersama dengan serbuk termoplastik untuk mendapatkan tempoh bersinar yang optimum dan akhirnya menganalisis sifat semua jenis bahan campuran yang dipilih. Sebatian strontium aluminat berbutir halus, SrAl2O4 telah dipilih sebagai serbuk bersinar dalam kegelapan yang paling sesuai sebagai bahan campur untuk cat garisan jalan. Berdasarkan analisis makmal, nisbah serbuk bersinar dalam kegelapan yang sesuai digunakan bersama dengan serbuk termoplastik adalah 55% daripada jumlah keseluruhan campuran untuk mendapat tempoh bersinar yang optimum. Purata tempoh bersinar dalam julat yang boleh diterima adalah 20 m. Ini juga merupakan jarak yang sesuai untuk mengecat garisan jalan kerana jarak penglihatan yang tinggi diperlukan di jalan raya ketika memandu dalam keadaan gelap atau malam.

Kata Kunci: Garisan jalan; cahaya lampu; kilauan; cahaya dalam gelap; termoplastik

INTRODUCTION

Mobile transport, cars, and cargo on the road is growing rapidly. In this context, the role of technical methods that should be provided for the movement organization were also increased. A routine examination of the highways is the main component of the operating maintenance. Continuous control allows the estimation of deformation of road line materials to determine the critical size of the flux and the causes of their occurrence, forming the necessary steps under adverse prevention (Balzannikov et al. 2016). The influence of the environmental factors on the workability of the highway system is expressed as an influence on the intensity of the road line materials which is the cause of the change in the workability culture of road maintenance (Gvozdovskiy & Evdokimov 2014).

To accept rational road maintenance, the negative effects of these factors can be reduced or excluded entirely (Dormidontova 2014). The road line mark has some features as it is possible to record its efficiency. The symbols and divisions of the mark indicate the possibility of defining the boundary of the movement, the site where parking is prohibited or restricted, places of transportation stops, as well as place arrangements for pedestrian crossings. Since the mark is possible to provide safety, both for pedestrians and drivers, to avoid road accidents (Goverdovskaya 2014).

The glow in the dark concept is tried in Netherlands where a road was built using solar panels that are arranged in a serial manner. The principle of these solar roads is that they can store high amount of energy which can be then transformed in the form of electricity. The energy generated leads to some level of self-sufficiency that can light roads, local amenities, and homes. The glow in the dark project is currently under trial and a stretch of 500 m of road in the N329 Oss Highway has been constructed. These roads apart from glowing in dark also give information regarding the conditions of the weather. This also supported by life cycle assessment (LCA) that had been used to assess the environmental impact of a product throughout the design phase. These need to be considered for a sound and safe road design with proper signage.

Patents such as "Chemiluminescent Signal Devices" were issued in the early 70s which are used for signaling in naval industries. Thomas Hall and Clarence Gilliam designed and patented the "Chemical Lighting Device" in 1973 (Patent 3, 764,796). Since it is not very clear for the first glow stick for play, Richard Taylor Van Zandt (US Patent 4,064,428) was issued a first glow stick in December 1977. After that, many toy glow sticks were built using the original design by Zandt (Patent US2341583 & Patent US2898825 2017).

The road marking cannot be seen without the addition of tiny glass beads. This is done during the application of thermoplastic line. The maximum reflectivity can only be achieved with the maximum embedment of the glass beads whereby 60% of the bead embedded below the pavement line or marking materials. Round sphere beads can give optimum retro-reflective. The road marking should be visible at any time of the year in different weather conditions. The chosen color such as yellow, white or orange for road line will not be heated up on the sun but in return will reflect light stronger and absorb nothing. The yellow color will have strong visibility in black asphalt. This normally will be used for prohibition of stop, for parking or zebra crossings.

Luminescent materials or phosphors, will discharge light after absorption of light from any light source. They are classified by their chemical family, excitation source or even the application. As excitation, they can be classified as thermoluminescent, X-ray luminescent, photo luminescent, electroluminescent, sonoluminescent, chemiluminescent, cathodoluminescent, triboluminescent, and bioluminescent (Robinson & Schmidt 1984).

Normally, the thermoplastics for road application will consist of glass beads, mixture of pigments, filler materials, and the binder. But this will be varied based on their grade of material that the provider intended to produce. Thermoplastic material shall be heated and melted down in a boiler with stirrer to avoid the discoloring and overheating. This will be done at the temperature of 180 oC for yellow and 200 oC for white. Then the thermoplastics will melt into the upper surface of the asphalt. The glass beads will be applied concurrently during the work (Prolongo et al. 2006).

The next material are the epoxies which can be categorized under the group of high performance bonding agent such as cyanoacrylate, polyurethane, and acrylic. The adhesives can be opaque and transparent with the help of hardeners. Normally, these adhesives can be applied to create the bonding for industrial applications (Prolongo et al. 2006). A clear epoxy resin which is used for super-high gloss finish is another type of adhesive. The resin normally is used for final touch on almost everything like stone, wood, clock, plaques, ceramics, and other materials (Prolongo et al. 2006).

Glow in the dark is another type of luminescence, these materials can keep the energy and as a source of light. This is called as phosphors. Phosphors will energize and then radiate light. This is called as phosphorescence. When phosphors release energy, they will emit light which will be glowing. Glow in the dark materials are divided according to technology and the process in which they produce light. The different types of glow technologies are chemical glow, UV light glow, and phosphorus glow (Wiese et al. 2015)

The light energy emitted from a substance is measured by the luminous intensity. The unit is candela, or can be measured with the amount of light generated by one candle. Normally, the comparisons are reported using millicandela per square meter, mcd/m2. Photometer is used to measure the luminosity. A photometer is an instrument that measures light intensity or optical properties of solutions or surfaces. Light will be measured after it has passed through a filter or monochromator to determine the wavelength and spectral distribution (Newworldencyclopedia.org 2019).

In the situation of almost total darkness, the eye changes significantly as displayed in scotopic curve. At 550 nanometers, the curve peaks. The fluorescent penetrant is designed to fluoresce near to 550 nanometers which can produce optimal sensitivity under dim light condition. Based on this, the yellowish green color is the brightest color among others. Therefore, this color can be applied for road markings as suggested in this paper.

METHODOLOGY

The method that was involved in selection of suitable type of glow in the dark material was by selecting optimum mixing ratio of the glow in the dark powder and thermoplastic powder and then analysed in the laboratory to select the properties of the type of the material chosen as shown in Figure 1. The suitable glow in the dark material will be selected based on the following criteria such as the colour, particle size, and workability of the material with the epoxy resin. A glow in dark material simply requires chemicals that store energy when exposed to light. Among those types of glow in dark materials, (strontium aluminate compound, $SrAl_2O_4$) the phosphorus glow which also known as photoluminescent glow material is the best to be applied to achieve the objective. Thermoplastic powder and glow-in-the-dark powder need to be mixed well to produce better mixture solution. Adding the glow in the dark material into the mixture requires new mixing ratio of the materials.

The $SrAl_2O_4$ material can absorb surrounding light then slowly emitting the light. Materials that practice this method and technology can glow in the dark for years if they are exposed to adequate light. This gives an advantage in the argument of the material selection.

RESULT AND DISCUSSION

The optimum mixing ratio of the thermoplastic powder and the glow in the dark, $SrAl_2O_4$ was determined based on the industrial standard of 2:1. The optimum percentage of glow in the dark material was determined in this experiment based on the results obtained. Figure 2 shows the data of Lux meter reading of the 6 samples interval of 5 minutes for an hour.

The lux is the SI unit of illuminance and luminous emittance, measuring luminous flux per unit area. It is equal to one lumen per square meter. In photometry, this is used as a measure of the intensity, as perceived by the human eye, of light that hits or passes through a surface model of human visual brightness perception. One lux is equal to one lumen per square meter:

$$1\ lx = 1\ lm/m^2 = 1\ cd/m^2 \quad (1)$$

Figure 2 summarizes the results from the laboratory test to select an optimum percentage of glow in the dark material to include in the adhesive mix of clear epoxy resin and hardener. Based on the result, we can identify that the results are the same when the glow in the dark material, $SrAl_2O_4$ percentage were from 55% till 60%. Based on the result, it is recommended to use 55% of glow-in-the-dark material to be mixed with the adhesive solution by weight. For example, if, 100 g of thermoplastic powder is used then 55 g of glow-in-the-dark material should be used in the mix.

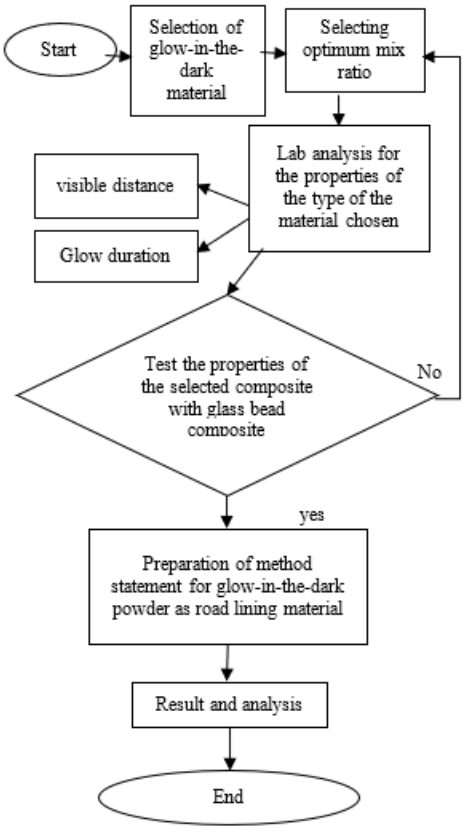

FIGURE 1. Material development flow chart

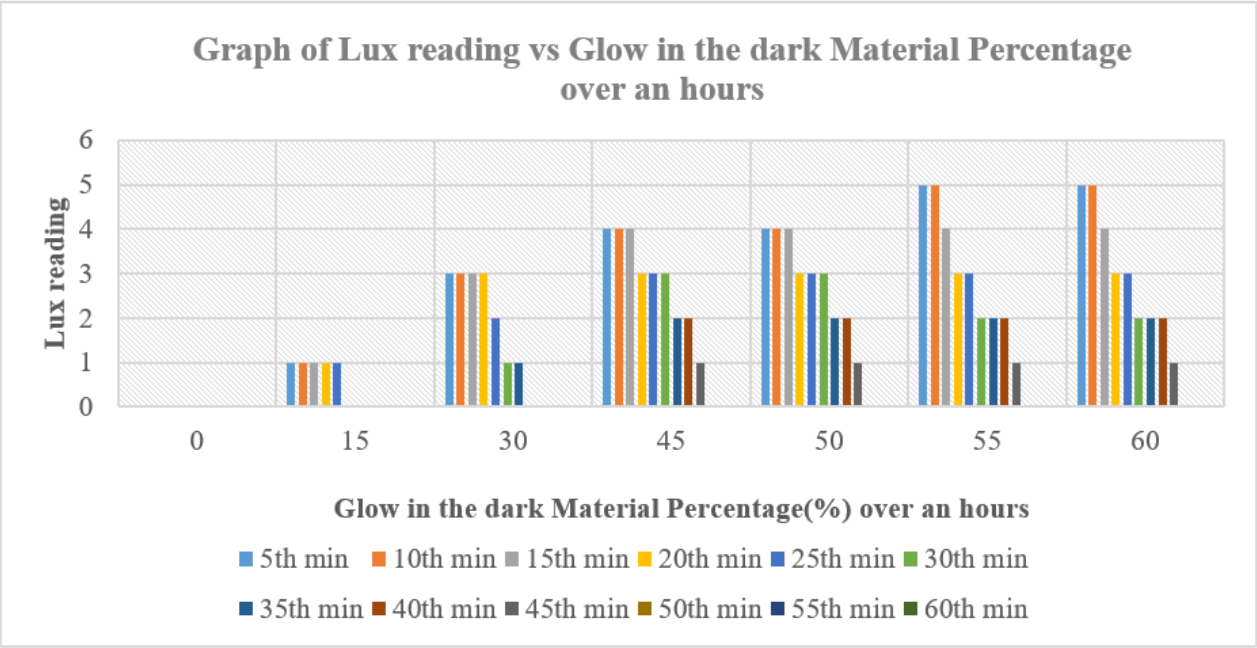

FIGURE 2. Graph of lux reading vs glow in the dark material percentage over an hour

Table 1 and Figure 3 summarizes the result of the laboratory luminance test. The result shows that the sample can give out visible light for 6 hours with the maximum lux reading of 5 luces and the minimum of 1 lux. Based on Table 1, the lux reading is still in visible range. Therefore, this glow-in-the-dark material will be suitable to be used in road line material as they are emitting visible light for 6 hours.

Table 1. Table of lux meter reading of 55% of glow in the dark material sample for 12 hours

Time	Lux reading [mcd/m^2] 55% of glow-in-the-dark material
1st hour	5 000
2nd hour	4 000
3rd hour	3 000
4th hour	2 000
5th hour	1 500
6th hour	1 000
7th – 12th hour	0

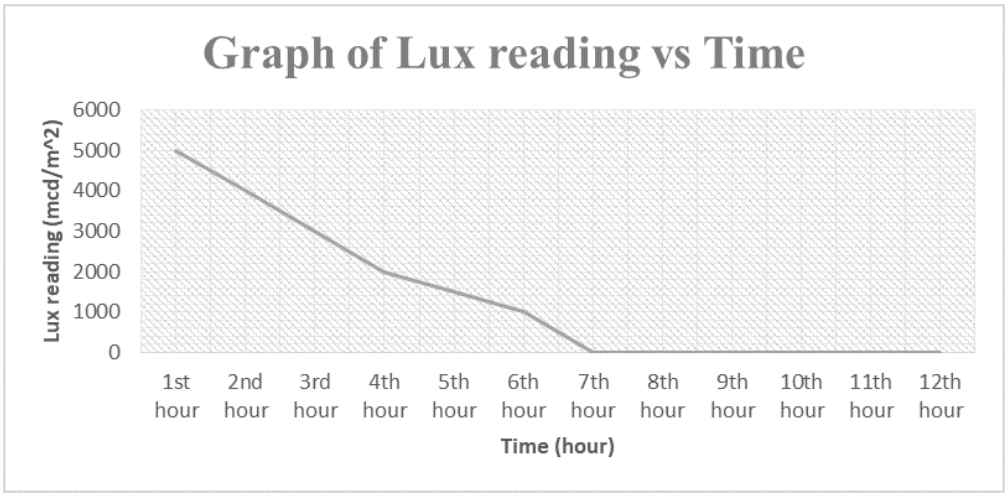

FIGURE 3. Graph of lux reading vs time over 12 hours

CONCLUSION

This research was conducted to study the suitability of glow in the dark material, SrAl2O4 to be used on road line material in Malaysia. Based on the analysis result, the fine granular of SrAl2O4 was selected as the most suitable type of glow in the dark material. Based on the laboratory analysis, the optimum ratio of the glow in the dark material to be used with thermoplastic powder is 55% in mass of the total mix volume. The average visible light emission period is in acceptable range which is 20 m. This is suitable distance to implement the road line because of the high visibility on the road during dark or night.

ACKNOWLEDGEMENT

Special thanks to National Defense University of Malaysia to provide the facility in Environmental Laboratory, Faculty of Civil Engineering, Universiti Pertahanan Nasional Malaysia.

DECLARATION OF COMPETING INTEREST

None

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