Research Article

A Research Study on Pigment Paste and Paint Contributing Energy Saving by Absorbing Energy from Light Sources and Emitting Light in the Dark

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Abstract

Glow in the dark (also called as photoluminescent) paints have the ability to absorb light from natural and artificial light sources and glow in dark medium. They can be easily charged since they have the ability to use ambient light (sun light, led lamps, fluorescent lamps etc.) as energy source. In case of emergency such as power outages occurred related to earthquakes and other natural disasters, the paint uses the energy absorbed and glows in the dark by emitting this energy in light form. Hence, it ensures safety by making emergency exits, stairs and information/safety signs visible for a while and prevent the accidents happen due to lack of lighting. Photoluminescent paints can also be applied onto light switches, baseboards, kitchen cupboard and decorative accessories. Besides, by the application of photoluminescent paint in tunnels and highways with intense vehicle traffic, the amount of energy used in both tunnel lighting and highways can be reduced by utilizing the light absorbed by the paint.

Within the scope of this study, waterborne photoluminescent pigment paste formulation was created and the pastes were produced primarily. Afterward yellow-green colored pigment paste was selected (from a group of pigments that has different colors) to be used as colorant in waterborne road marking paint, bike

lane paint, tennis court paint and hobby paint groups. The paint produced were applied onto test panels and luminance values and luminance time of the panels were measured.

Keywords: *Glow in dark pigment paste, Glow in dark paint, Photoluminescent pigment paste, Energy saving, Metal halide light source, Sodium vapor light source, Ambient light absorbing pigment paste and paint*

1. Introduction

Photoluminescent paints are capable of absorbing energy from sunlight and external artificial light sources. (Yan et al., 2020). They have good storage ability of energy and emit it in darkness (Yan et al., 2020 and Xiao et al., 2022). With the help of this useful property of the photoluminescent paint, they can be used in various beneficial application to reduce energy consumption and to use technological improvement in effective way to solve problems. Photoluminescent paint has a wide range of application areas. It can be used for road marking to increase the visibility in poor weather conditions and to improve the safety at night in urban areas and highways (Nance et al., 2020 and Bonneel et al., 2023). The headlights of the cars and road lighting will be used as an energy source by paint and then emit this energy in the form of light (Bonneel et al., 2023).
The usage area of photoluminescent paint are not limited to road markings. They can also be used to ensure emergency exits and safety signs are visible in darkness or during power outages (Al-Ahmed et al., 2023). Additionally, it can be used for decorative purposes to design home and office environments more enjoyable and dynamic. It is not only be preferred for decorative purposes but also to reduce consumption of existing amount of energy and economic aspects.

2. Materials and Methods

Within the framework of this study, it was aimed to examine the effect of the type of light sources and type of paint onto “luminance time” and “luminance performance” of the photoluminescent paint. Therefore, 2 different type of light sources;

- Metal halide lamps
- Sodium vapor lamps

were selected as energy source to charge the paint.

A sodium vapor lamp is a gas discharge lamp that utilizes sodium gas to generate light at a specific characteristic wavelength. However, the second light source, metal halide lamps has significant advantages. One of the key advantages of metal halide lamps is their ability to enhance color rendering and luminous efficacy, with a luminous efficiency ranging from 75 to 100 lumens per watt. This means they produce a substantial light output for the energy consumed.

In a wide range of indoor and outdoor paints; road marking paint, bike lane paint, hobby paint and tennis court paint were selected to be colored with photoluminescent paste and then applied onto test panels to examine the "luminance performance" and "luminance time". In the preparation of test panels, the following steps were performed for all four type of selected paints in the same way:

- To increase the luminance effect of the paint white colored paint was applied onto panels as primer.
- Then, photoluminescent paint was applied onto panels in 3 layers and allowed to dry completely.

Two different artificial light sources, metal halide lamps and sodium vapor lamps, were preferred in charging the panels with glow-in-the-dark paint applied. To observe the effect of individual light source on luminance time of paint, the same excitation and measurement procedures were carried for both light sources. The test panels were kept in laboratory for a few days to fully discharge their energy. Then, they were excited with sodium vapor light source for 5 minutes and the light source was turned off and luminance values of test panels were measured in every 5 minutes. After measurement procedures was completed, the panels were left in dark room to fully discharge of their energy and to be prepared for another set of testing which was repeated by using metal halide light source instead of sodium vapor light source.

The same test & measurement procedure was repeated using metal halide lamps in order to see the effect of the type of light sources on luminance performance. The results of the measurements (luminance performance and luminance time) of the each paint are presented in Figures 1 to 7.

3. Results

The luminance values of Road marking paint, Bike lane paint, Hobby group paint and Tennis court paint with respect to time are shown in Figure 1 to 4, respectively.

The results show that all group of paints (Road marking paint, Bike lane paint, Hobby group paint and Tennis court paint) have higher luminance value at the beginning when they are excited with metal halide lamps instead of sodium vapor lamps.

In each paint application, it is seen that there is a sharp decrease in luminance values in 10 minutes. On the other hand, after 10 minutes of luminance, it is seen that luminance values decrease slowly for each paint. When the effect of light sources is examined, it is

obviously seen that the panels excited with metal halide lamp has a greater luminance value (in cd/m²) at the beginning of measurement (0,16 min.) in each type of paint. In the comparison of luminance performance of each paint excited with both light sources, it is seen that the luminance values decreases slowly after 10-15 min. for both lamps.
Since the luminance values decrease very slowly approximately after the 20th minute of the measurements for both metal halide and sodium vapor lamps, the data measured in the first 120 minutes are presented in Figures 1 to 4.

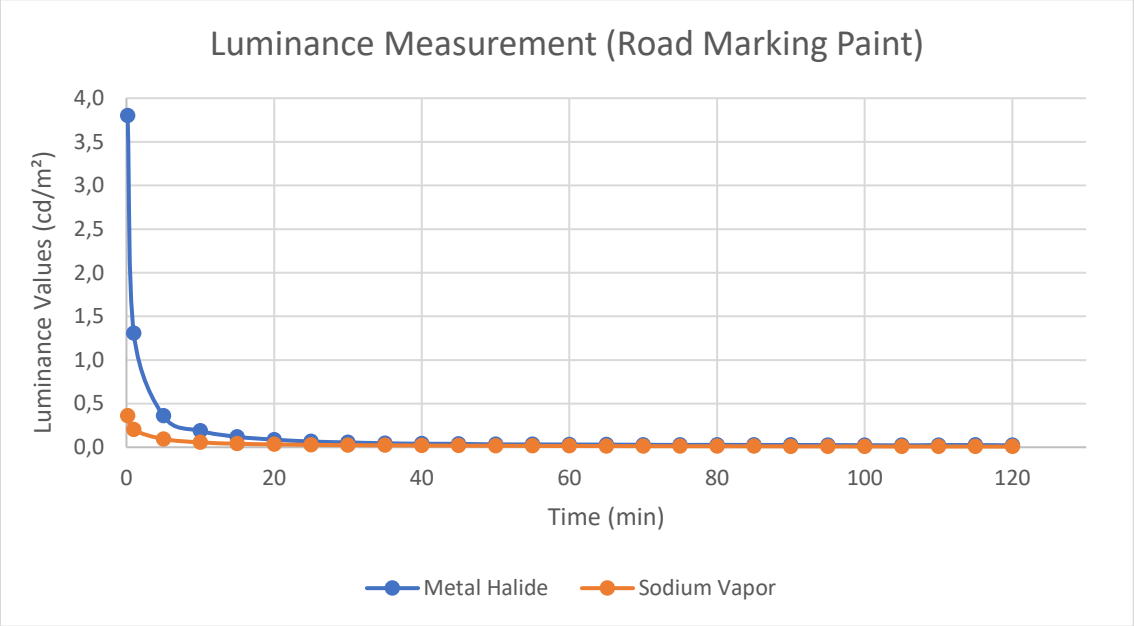

Figure 1: Results of luminance measurement of Road Marking Paint samples (Yıldız Technical University, 2022).

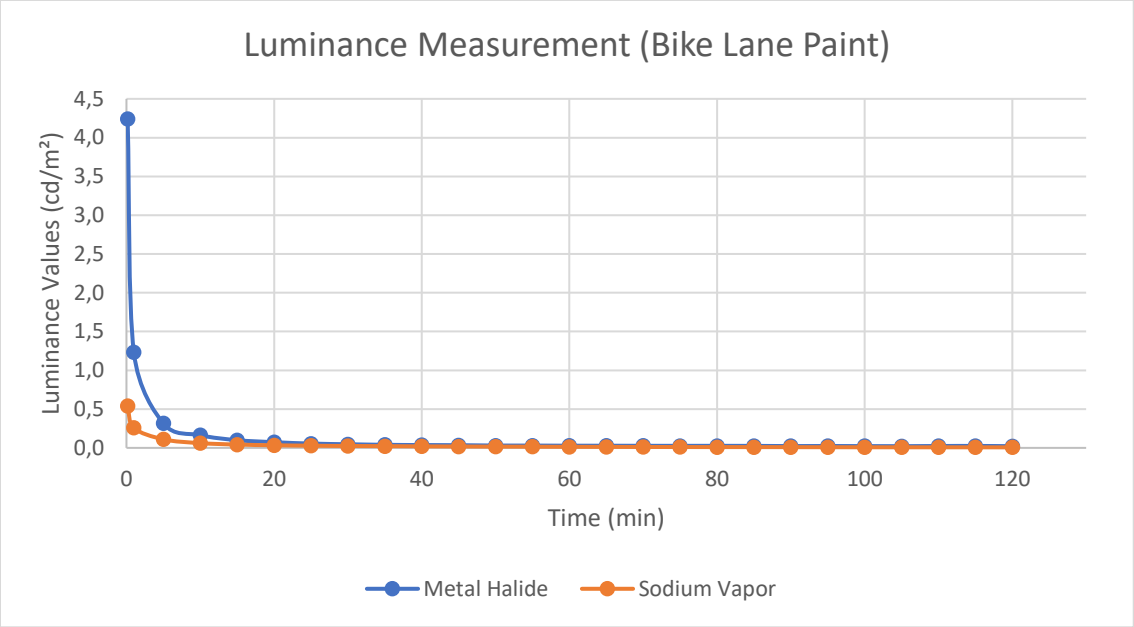

Figure 2: Results of luminance measurement of Bike Lane Paint samples (Yıldız Technical University, 2022).

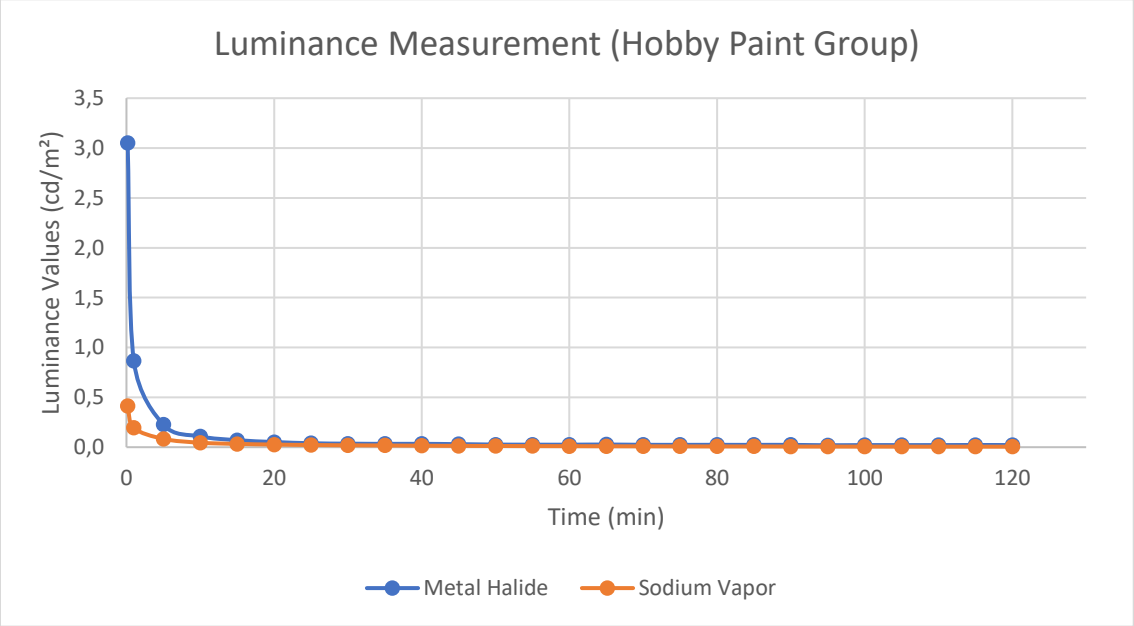

Figure 3: Results of luminance measurement of Hobby Paint samples (Yıldız Technical University, 2022).

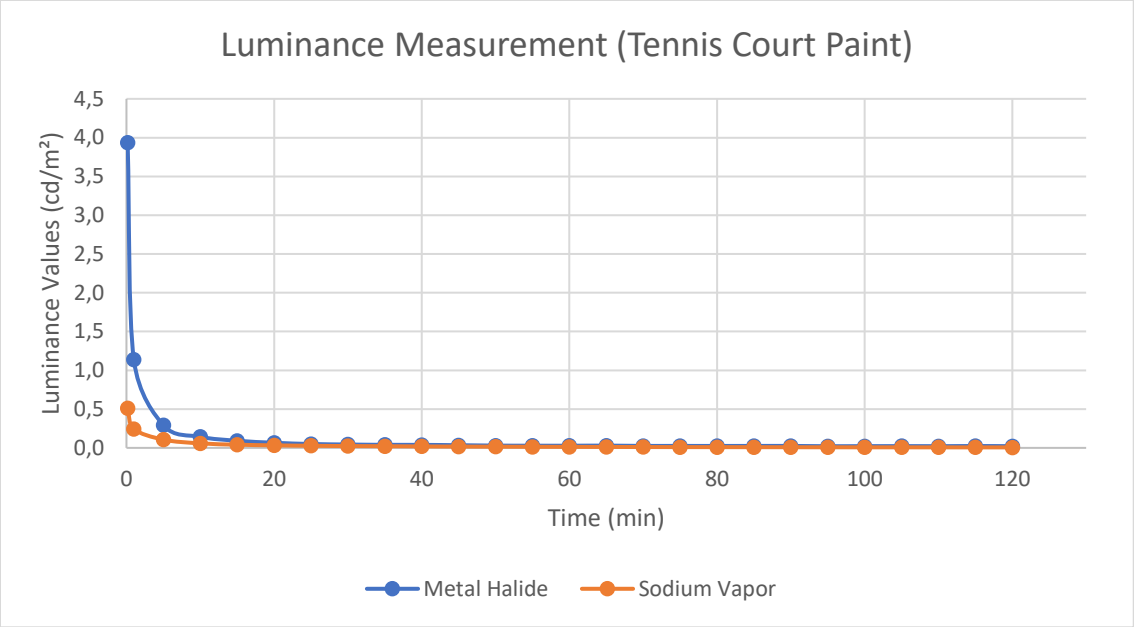

Figure 4: Results of luminance measurement of Tennis Court Paint samples (Yıldız Technical University, 2022).

The time required to reach 5 mcd/m², 1 mcd/m² and 0.1 mcd/m² of luminance values are presented in Figures 5 to 7. The effect of light source on luminance time are shown in these figures. According to the following three figures, panels charged with metal halide lamp have higher luminance value compared to the panels charged with sodium vapor lamps.

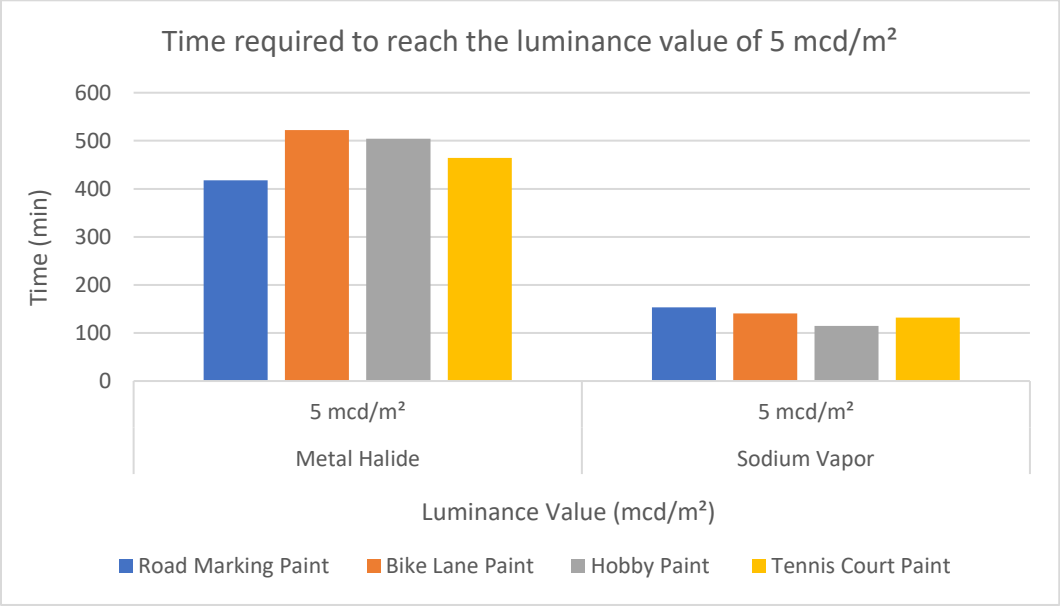

Figure 5: Time required to reach the luminance value of 5 mcd/m² for each type of paint samples (Yıldız Technical University, 2022).

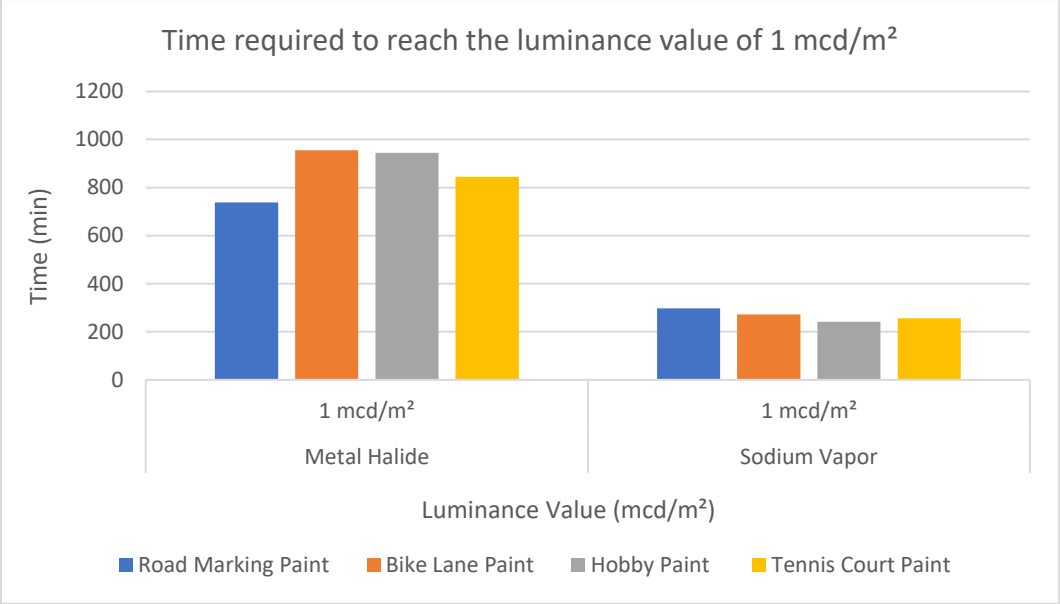

Figure 6: Time required to reach the luminance value of 1 mcd/m² for each type of paint samples (Yıldız Technical University, 2022).

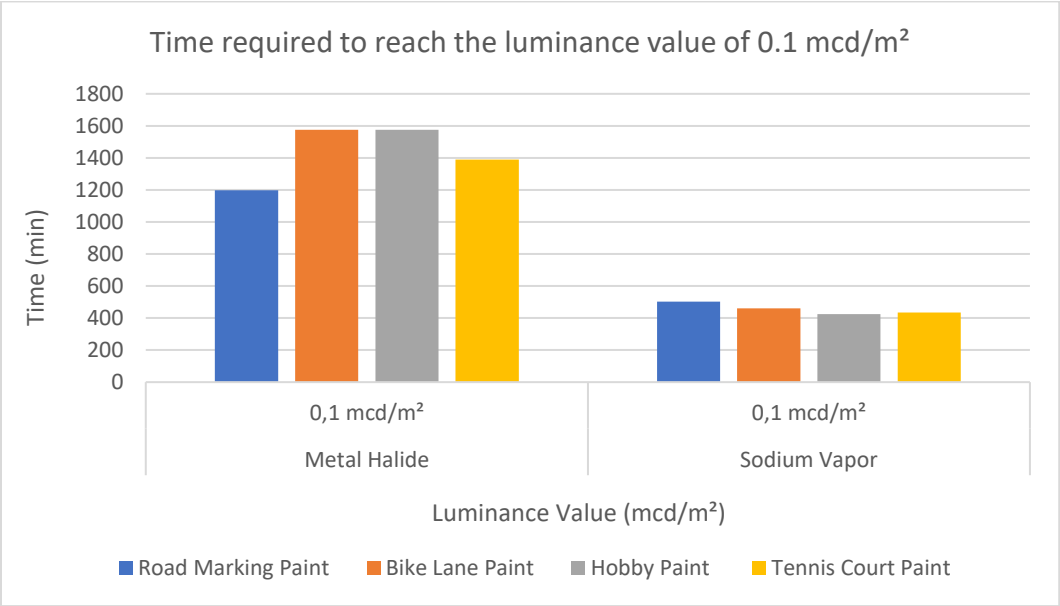

Figure 7: Time required to reach the luminance value of 0.1 mcd/m² for each type of paint samples (Yıldız Technical University, 2022).

4. Discussion and Conclusion

The measurements were carried out until 0.1 mcd/m^2 of luminance value was achieved for each test panel. According to the results obtained, test panels excited with metal halide lamps have luminance time of **1576.03 min.** for hobby paint, **1574.56 min.** for bike lane paint, **1389.87 min.** for tennis court paint and **1197.24 min.** for road marking paint to reach 0.1 mcd/m^2 of luminance value. On the other hand, **502.04 min**. for road marking paint, **460.57 min**. for bike lane paint, **434.86 min.** for tennis court paint and **423.81 min.** for hobby paint was required to reach 0.1 mcd/m^2 of luminance value for each test panels excited with sodium halide lamps.

It is seen from the results that the test panel coated with hobby paint has highest luminance time compared to other panels when metal halide lamps were used. However the same paint has the lowest luminance time when sodium vapor lamps were used instead of metal halide lamps.

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