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Modified Recycled Glass as an Additive in Coatings Applications

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MODIFIED RECYCLED GLASS AS AN ADDITIVE IN COATINGS APPLICATIONS

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ABSTRACT

The feasibility of using chemically modified, finely pulverized recycled glass as an additive in coatings was investigated. The ground glass was added as partial replacement for the conventional pigment titanium dioxide (TiO_2). The loss of TiO_2 pigment was compensated with an optical brightening agent (OB agents). OB agents can help contribute to a coating's hiding capacity by absorbing light in the UV range, releasing light of a lower energy in the visible spectrum. Glass supplemented coatings were formulated and common paint tests were performed. The glass changed the optical and physical properties of the coating formulations. The results of the project demonstrated the feasibility of using recycled glass as an additive in coatings.

INTRODUCTION

This project was conducted to investigate the feasibility of using chemically modified recycled glass as an additive in coatings. The chemical modification tested in this project involved the addition of an optical brightening agent (OB agents). This type of usage of recycled glass could be beneficial for several reasons including development of a possible market for recycled glass plus the reduction of other more expensive pigments in coatings such as titanium dioxide (TiO_2).

An OB agent is a chemical that can absorb light in the ultraviolet region and then re-emit light in the visible region. The OB chemicals are also called Fluorescent Whitening Agents (FWA's). [1] Addition of these agents contribute to the hiding capacity of a coating and can also yield an entirely new type of pigment for coatings.

With the replacement of the commonly used pigment TiO_2 by glass, the new coating will display changed properties. The changes in optical properties include hiding capacity and maximum reflectance of light. Altered physical properties include scrub resistance and viscosity.

POSSIBLE ENVIRONMENTAL IMPACT

A potentially significant impact of this project is finding a new market for recycled glass. The U.S. produces a large amount of glass and could benefit economically with a new market for recycled glass. The annual amount of waste glass generated in the Ozark Rivers Solid Waste Management District is listed in Table I. [2]

TABLE I

WASTE GLASS GENERATED ANNUALLY IN OZARK RIVERS SOLID WASTE MANAGEMENT DISTRICT

Amber Glass		1,128 Tons
Green Glass		1,025 Tons
Clear Glass		3,280 Tons
	TOTAL	5,433 Tons*

*The total waste glass generated is equivalent to 360 lbs/per person/ year.

This amount of glass could potentially be utilized and help reduce some of the 1 million tons of TiO_2 used in the coatings industry.

METHODS OF PROJECT

The first step was grinding the glass. This was done by a local company and provided to us by Mo-Sci Corporation. The grinding of the glass used in this project was done with a roller mill and was obtained in a variety of sizes. Other glass samples were obtained from treatment with an air cyclone. This latter glass was not used because it was not of high enough quality, having a gray tint, and it did not consist of sufficient small particles. A list of the sizing of the glass is shown in Table II.

Table II.

PERCENT OF GLASS IN EACH SIZE RANGE - COMPARISON OF TWO GRINDING METHODS

Size in μM	Milling	Cyclone
> 150	43.11%	53.85%
150 - 106	10.86%	13.19%
160 - 75	16.33%	12.93%
75 - 45	12.90%	11.28%
< 45	16.80%	8.75%
Total	612.4 grams	890.2 grams

Two different phases of the project were conducted once the glass was milled. The first phase was performed to determine if untreated glass could be added to a coating without drastically changing the performance properties of the paint. This involved preparing and testing various formulation of water-based latex paints. The glass replaced the TiO_2 in 2.5% increments by weight up to 20% of the TiO_2 pigment, which is approximately 2.5 pounds per gallon of paint. The Table III lists the basic paint formulation used in the study.

TABLE III

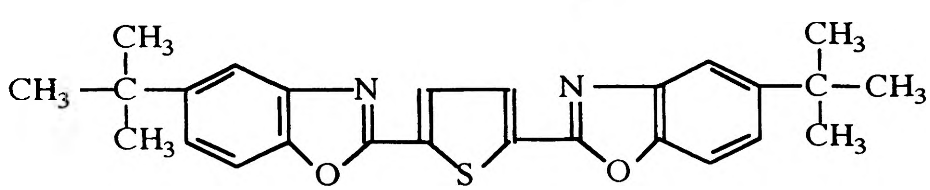
COATING FORMULATION

Chemical	Amount Used in Grams
Natrosol 250 HBR	1.8
Water	12.9
Tamol 850	112.0
Trition N-101	4.6
Colloid 643	1.0
KTTP	0.5
Minex 4	125.0
Optiwhite	25.0
Combination of TiO_2 and glass added in 2.5% increments	125.0
UCARA 525	214.0
Butyl Cellosolve	8.5
Colloid 643	1.3
Nept 95	4.5
NH_4OH	1.8

Tests were then performed on the coatings for each formulation to determine what properties changed with each addition incremental of glass. The tests performed included grind to measure the particle size, scrub resistance, viscosity, and flexibility on a metal panel.

The second phase of the project was the incorporation of the OB agent onto the surface of the glass. The chemical used for this was 2,5-bis(5-tert-butyl-2-benzoxazolyl)thiophene (BBTP), whose structure is shown in Figure I.

FIGURE I



CHEMICAL FORMULA OF THE OPTICAL BRIGHTENING AGENT

The BBTP organic molecule was bonded to the inorganic surface of the glass with the use of a silane coupling agent. Silane coupling agents are commonly used to bond organic material to inorganic material. The silane coupling agents have two main groups and have a generic form of X_3-Si-RY. The 'X' determines the bond to which the inorganic material and the 'RY' is an organic segment with functionality 'Y,' which is used to bond to the organic molecule. In this case, the organic molecule was the OB agent. Exact information of how this is done is considered proprietary, because a patent may be sought on the OB glass.

Once glass was treated with the OB agent, new coating formulations were developed and tested. Coatings were made of the same formulation in Table I, but with 5%, 10%, and 20% substitution of OB modified glass. These three formulations were compared to the same percentages of untreated glass. Two other formulations were made for the Missouri Highway Department and then tested against their specifications.

RESULTS

The coatings made with the variable amount of glass showed several different physical properties. The increase in glass caused a rise in the viscosity of the formulation. With the incorporation of the hard glass into the coating, the scrub resistance was improved although the flexibility was reduced with a high loading of glass. The decrease in some properties, such as an increase in viscosity and grind, with the higher loadings of glass will probably limit the amount of glass that can be added into a formulation. The main optical property of concern, hiding capacity, was lowered with the inclusion of the OB glass and plain glass when compared to no glass substitution for TiO_2. When the same percentages of OB glass were compared to plain glass, the OB glass did have more hiding capacity than the plain glass.

Some tests were performed using test specifications developed by the Missouri Highway Department. Test formulations met most of these requirements as shown in Table IV. With additional revision of the experimental formulations, all of the test requirements should be met. The results of the OB glass in two model traffic formulations are shown in Table IV.

TABLE IV

MODEL TRAFFIC PAINT FORMULATIONS COMPARED TO MISSOURI HIGHWAY DEPARTMENT SPECIFICATIONS TTP-1952B

TEST	REQUIREMENT	WHITE	REQUIREMENT	YELLOW
Viscosity	70-90 KU	70 KU	70-90 KU	71 KU
Storage Stability	70-90 KU	73 KU	70-90 KU	69 KU
Total Solids	50% min	57%	67-75%	69%
Drying Time	75 min max	pass	75 min max	pass
Flexibility	pass (1/8")	pass	pass (1/8")	pass
Scrub Resistance	400 cycles	390 cycles	400 cycles	380 cycles
Dry Opacity	0.92 min	0.96	0.92 min	0.97
72 hour Water Resistance	pass	pass	pass	pass
Freeze Thaw, 3 cycles	pass	pass	pass	pass

* Formulation with a 20% substitution of glass for TiO2

Tests were done to show that the OB agent was bonded to the glass, including infrared red (IR) and ultraviolet (UV) spectroscopy, shown in Figure 2 and Figure 3 respectfully. The evidence to qualitatively show that the OB agent was attached to the surface of the glass was the appearance of the modified glass. The OB agent is a bright yellowish-green powder and the glass is a white powder. The modified glass was a yellow-green powder. When the modified glass was placed inside a UV-black box, it would fluoresce in a similar manner to the OB agent.

The spectroscopic test to determine the OB to glass loading were not conclusive. Inferred spectra were run on a sample of the OB modified glass and compared to the untreated glass. The spectra were almost identical and the spectra inclusive, as can be shown from comparison of the two spectra shown in Figure 2. The UV spectra of the two samples also did not show any significant differences, as shown in Figure 3.

FIGURE II

Comparions of Spectra of OB modified Glass And Untreated Glass

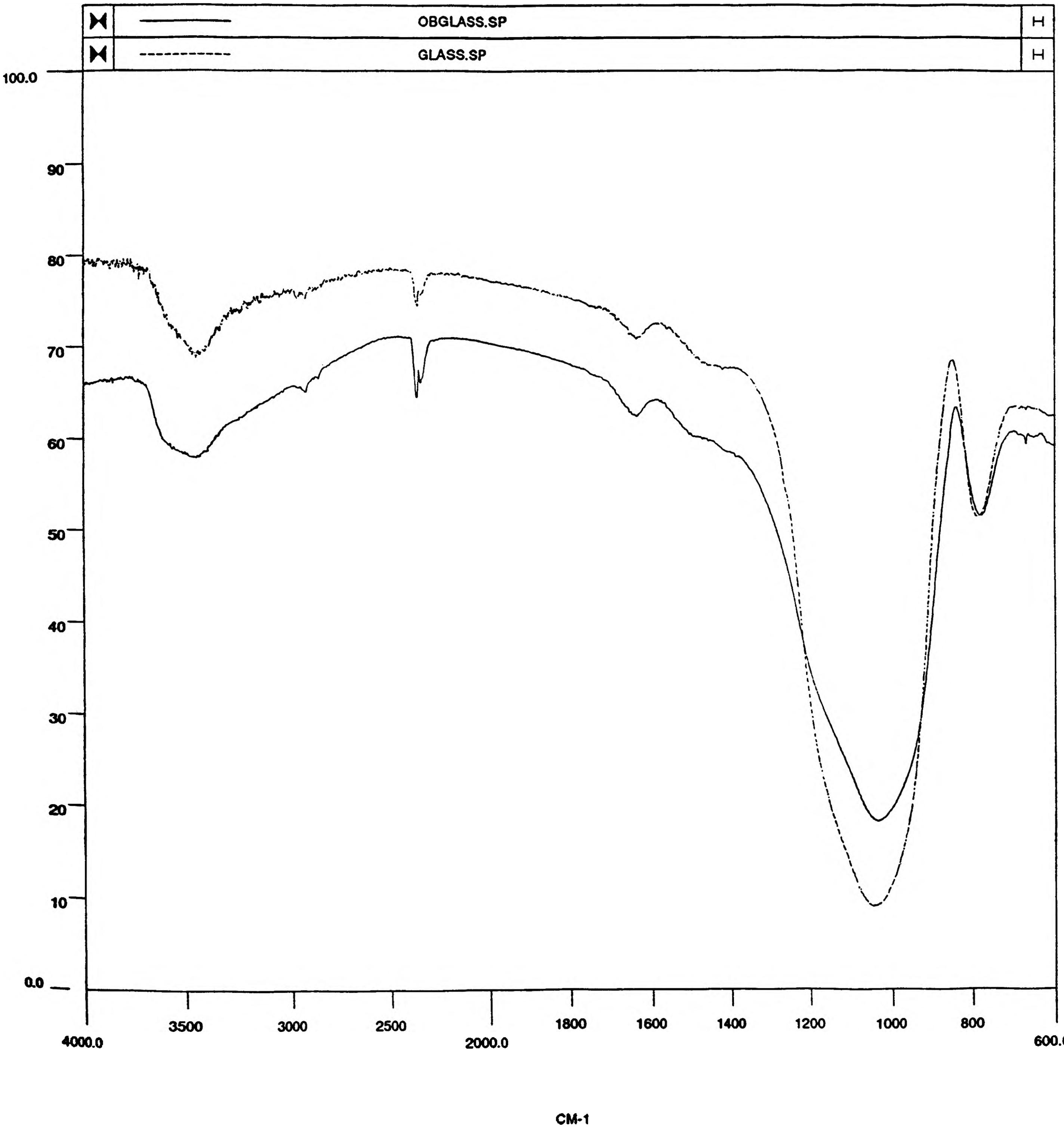
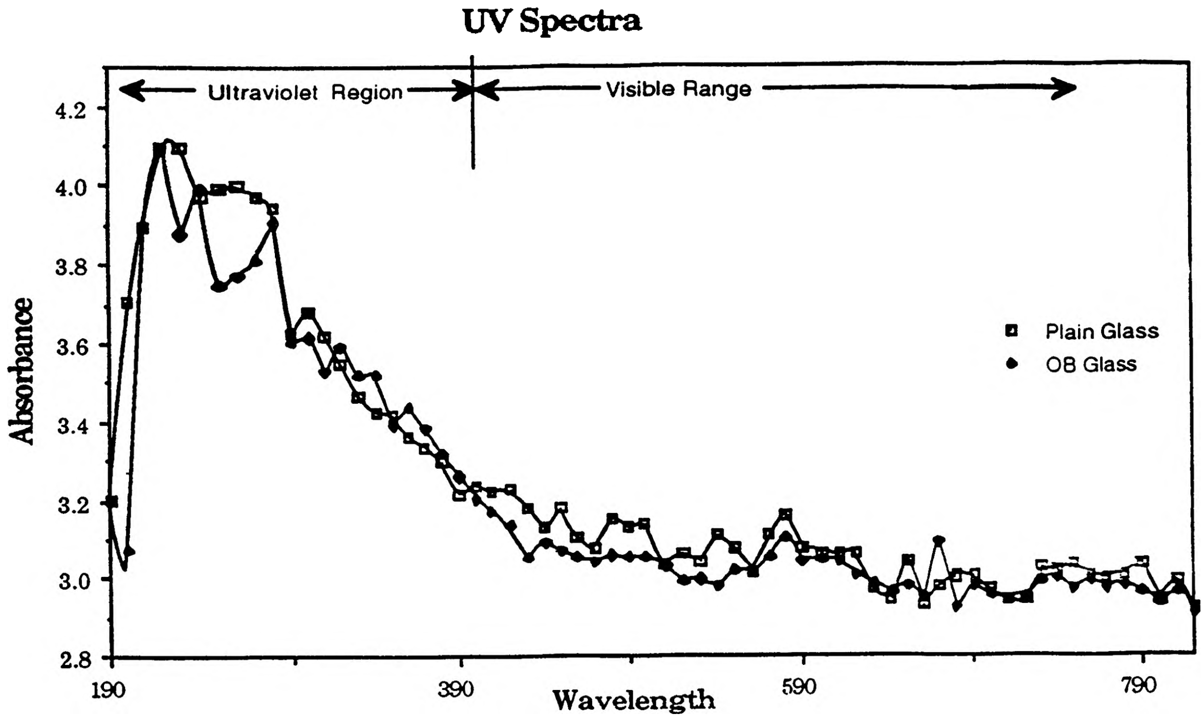


FIGURE III



The inconclusiveness of the tests comes from a few factors. The largest factor was the concentration of the OB agent on the glass surface. When each spectrum was run, the samples had to be of a low concentration within a suspending material. The suspending material for the IR was potassium bromide (KBr) and for the UV spectra, the suspending material was in a nujol mol, a gel to suspend a solid allowing a spectra to be obtained. Within the samples, the concentration of the OB agent would be very small and unmeasurable with the instrumentation used. Another factor may have resulted from the glass absorbing some of the light. This was more important in the UV spectra where glass will absorb ultra violet light and is therefor opaque in the UV spectrum.

CONCLUSION

In this project, the feasibility of using modified recycled glass was studied. It was shown that recycled glass can be added to some coatings without a large change in the performance properties of the coating. The OB agent was also shown to be attached to the surface of the glass and to partially compensate for the reduced amount of TiO_2 in experimental coatings.

When the experimental paint was applied to the test surfaces, the glass particles caused a rough texture. This roughness makes the coatings applicable to be used in traffic coatings, where the artistic value of the coating is not as important. The use of these coatings for highway traffic coatings is of interest to the Missouri Highway Department. This roughness could be lowered by using a smaller particle sizes of glass and by allowing the paint to be ground up longer during formulation.

If glass is incorporated into formulations, the project could have a positive environmental impact. It will allow for a recycled product to have a new market and reduce the need for other newly processed material.

REFERENCES

1 Lambourne, R. Paint and Surface Coatings. 1987.

2 Information provided Ozark Rivers Solid Waste Management District

3 Petrarch Systems. Silicon Compounds. 1987.

ACKNOWLEDGMENTS

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