Assessing the Chemical Durability of Textured Glass-Coat for Building Application

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The need to assess the chemical properties of coats produced for building applications is of essence, especially in an acidic or alkaline environment. To determine this property, this study investigates the reactions of textured Glass-coat to chemicals. Samples of textured glass-coat developed from Post Consumer Glass (PCG) were subjected to Adhesion test (ASTM D3359), pH test (ASTM D5464), Chemical resistance test (ASTM D3260 and D1308), and Abrasion test (ASTM D4060). Results show an adhesion of 4A and a pH of 8.50 respectively. The chemical resistance result shows the following: A 5% flick rate was observed when reacted with Sodium hydroxide (NaOH) solution; decolouration with the following solutions was observed: Magnesium hydroxide ($Mg(OH)_2$) 3% decolouration, Hydrogen Fluoride (HF) 5% decolouration , Potassium hydroxide (KOH) 7% decolouration and NaOH10% decolouration was observed. Also, the analysis show that the coat exhibits 0.2g abrasion rate. The results from the analysis confirm that the developed textured glass-coat is in line with the pH standard which ranged from 8–9 (ASTM D5464), significant resistant to acid and base solutions were observed except for HF, NaOH, KOH and $Mg(OH)_2$ where a negligible flick rate and colouration defects was observed. Also, based on the result, an excellent adhesion and abrasion properties was established. Finding shows that the developed Glass-coat exhibits excellent resistant to chemical degradation especially in an acidic situation and it is recommended as a suitable engineering material for building applications.
Keywords: Glass-coat, PCG**,** Chemical durability, Building application

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INTRODUCTION

Chemical tolerance is one of the basic factors considered during material development whose effects account for the acceptability and applicability of the material as such, material producers considered these factors during production (Macko *et al.,* 2018). Coatings, or coats, are materials whose applications cut across most fields of endeavour due to its unique properties which is beyond aesthetic (Kc *et al.,* 2017). These materials vary in type depending on their areas of application and consumer choice, as such, they range from acrylic, alkyds, epoxy, and polyurethane, and based on their texture, i.e., emulsion, oil-based coating, and textured coating, to mention but a few (Liu *et al.,* 2019). Texture coating is a type of decorative and protective coating that adds texture and visual appeal to various surfaces. It is composed of aggregates such as sand, talc, glass cullet, stone, or polymer particles mixed with a binding agent (Advameg, 2014; Adejo, 2022). This mixture is applied to surfaces such as walls, ceilings, or furniture to create a textured finish with unique aesthetics and improved surface durability. A glass coating is a type of texture coating that contains post-consumer glass as a texturizing agent in the presence of a binding agent to create a durable and visually appealing surface (Soltani-Kordshuli *et al.,* 2023). The use of textured coatings, such as glass-coat, provides both aesthetic appeal and enhanced durability for surfaces such as walls, ceilings, and exteriors.

The effect of chemicals on the coating is a factor that should be carefully considered, as certain chemicals, especially in the areas of application, have the tendency to damage or degrade the coating (Mai *et al.,* 2020). Since the quest for urbanization continues to be on the rise, this has directly affected the demand for buildings for habitation and for other purposes, as the need for durable coatings for building finishes is also required. Over the years, coating industries have been developing, while technology continues to play a significant role in this development. None the less, this material has faced diverse forms of challenges and deterioration, ranging from chalking, crazing, blistering, peeling, loss of colouration, flaking, and other forms of degradation that can be traced to defects in its optical, microbial, mechanical, chemical or physical properties (Jirouš-Rajković & Miklečić, 2021).

According to Special-Chem (2023), coating on the surface of a substrate works mainly as a protector from external defects such as strains, interactions, or a harsh environment that can occur naturally or induced by man's activities. However, the coat becomes subjected to degradation when in contact with chemicals mostly during cleaning and it results in different forms of degradation ranging from crazing to flicking, to mention but a few. Also, the effect of chemical attacks on coatings can further lead to swelling, discoloration, adhesion loss, gloss reduction, and blistering, which mostly result in deterioration of performance and eventual failure under certain conditions. As such, it is important to study the behaviour of this material with respect to its interactions with chemicals.

The importance of coatings on the surface of any material is a phenomenon. In this light, Bibi *et al.* (2015) observed that even structures built with the best of concrete are prone to developing durability problems, which are mostly the result of the deterioration of concrete when exposed to harsh environmental conditions. As such, in order to mitigate the onslaught of concrete, protective coatings with chemical resistance are required. Also, in the studies of Noor *et al.* (2012), Mirza *et al.* (2013) and Bhutta *et al.* (2023), it is revealed that regardless of the composition of concrete, without coating it is prone to deterioration, which in most instances is chemically induced due to the ingress of chemicals such as chloride, sulfate, and ammonium ions and carbonation stress leading to the alkali-silica reaction of the concrete.

In order to address the aforementioned challenges and ensure the longevity and performance of the textured-building glass-coat, it is important to evaluate the chemical compatibility of the coating with a view to assessing its tolerance and durability level without compromising the coating's integrity.

RESEARCH METHODOLOGY

The methodology of this study will evaluate some mechanical (Abrasion and Adhesion test) and chemical (pH test, Acidity and Alkalinity test) properties and the ASTM standard techniques will be adopted. Adhesion test was conducted on the produced glass-coat according to ASTM D3359 (2017), in order to determine its binding ability to the substrate. The standard tape test method A was adopted since the coat film thickness is greater than 125mm. Samples of the produced glass-coat were applied to a flat metal sheet so that it was freed from blemishes and minor surface imperfections, then allowed to dry at room temperature. The plate was placed on a firm base, in a steady motion, and the dried glass-coat was cut through using a clean sharp straightedge cutting knife. The glass-coat was cut into two at a length of 40mm making an intersect in the middle with a small angle range of 30º and 45º to make an X inscription, so as to make the metal sheet visible. Using a standard masking tape of 2.5mm in width, two revolutions of the tape were cut off from its roll, and 75mm of the tape was cut and placed on the centre of the intersection of the cut glass-coated plate such that it ran in the direction of the smaller angle. It was smoothed using a finger in the area of the incisions so that entrapped air was removed, and the tape was rubbed firmly with some pressure until the colour appeared uniformly on the coated surface. Seizing the free end of the tape, it was pulled off rapidly backward at an angle of 180° after every 60 seconds of application. This test was carried out three times, respectively, on the produced coat and the result presented.

This study was conducted to determine the acidity or alkalinity of the produced glass coat. A sample of the produced glass-coat was collected and subjected to pH testing in accordance with the ASTM D5464 (2011) standard. The pH meter was turned on, calibrated in a buffer solution, and the tip of the electrode was inserted into a container containing the produced glass coat. Readings were taken and recorded accordingly.

A chemical resistance test of the coat was conducted to determine the reaction of the glass-coat with household chemicals, *u*sing the standard test method for the effect of household chemicals on clear and pigmented coating systems as ascertained by ASTM D3260 (2017) for acid resistance and ASTM D1308 (2013) for alkali resistance on the coat. To carry out this analysis, a sample of the produced glass-coat was applied to a flat plate measuring 50mm by 120mm and allowed to dry at room temperature. The plate was coated by the edge with paraffin and bee wax in a mix ratio of 1:2 in order to avoid the edge sipping of the acidic solution into the coat. The acid resistance procedure was conducted by immersing the dry coat in a 10% concentration of acidic solution, i.e., HF, HCl, H_2SO_4, and NHO_3 respectively at an ambient temperature of 25ºC for 6 hr. The coated plate was rinsed, dried, and examined for defects such as blistering, peeling, lifting, crazing, flaking, and discoloration.

In determining the glass-coat reactions to alkaline chemicals, the same procedure used for acidic analysis was adopted.

Sample of the produced glass-coat was applied to a flat plate measuring 50mm by 120mm and allowed to dry at room temperature. The plate coated with glass-coat was coated by the edge with paraffin and bee wax in a mix ratio of 1:2 in order to avoid edge sipping of the alkaline solution into the coated plate. The coated plate was immersed in a 10 % concentration of an alkaline solution of KOH, NaOH, CaOH, and MgOH, respectively, at ambient temperature of 25ºC for 6 hours. The coated plate was rinsed, dried, and examined for defects such as blistering, peeling, lifting, crazing, flaking, and discoloration.

In order to determine the aggregate flick rate of the coating after exposure to an acidic and alkaline solution, a standard abrasion resistance test for coatings was conducted using ASTM D4060-19. In doing this, a sample of the produced glass-coat was applied uniformly to a plate, it was allowed to dry hard at room temperature, and the weight of the coated plate was determined using a Mettler balance. Using a Taber abraser of a known weight of 3.5 kg, the coated plate was kept in a rigid position, and the abraser was used to make a 60-cycle rotation on the sample, after which the weight of the coated plate after abrasion was determined. The abrasion rate was determined using the formula below.

$$Z = x_1 - x_2 \quad \text{ASTM D4060 (2019)}$$

Where:

Z=Abrasion Rate

X_1 =Weight of coated plate before the test

X_2 =Weight of coated plate after the test

RESULTS AND DISCUSSION

Adhesion Test

The result of the Adhesion test on produced Glass-coat (Table 1) shows the binding ability of the coat to surfaces, the study established that the developed Glass-coat exhibits a 4A binding ability. This implies that less than 5% flick rate of coarse aggregates will be noticed and that the produced Glass-coat exhibit a very good binding ability to surfaces, and conforming with the ASTM Adhesion scale (5A=0% flick rate, 4A=less than 5% flick rate, 3A=5-15% flick rate, 2A=15-35% flick rate, 1A=35-65% flick rate and 0A= Grater that 65% flick rate) (Dilik *et al.*, 2015) and (ASTM D3359, 2017) as compared to conventional coating whose adhesion value is mostly below 3A classification.

Table 1: Adhesion test on produced glass-coat

S/N	Glass-coat colour	Classification	% of Removed area
1	Yellow	4A	Less than 5%
2	Red	4A	Less than 5%
3	Blue	4A	Less than 5%
4	Black	4A	Less than 5%

pH Test

The result in Table 2 shows the pH analysis of the produced glass coat. This analysis was conducted to investigate the behaviour of the material, viz., its acidity and alkalinity. The result demonstrated that the developed glass coating was alkaline in nature, despite the variation in the pH values, which might be influenced by the colorants or vice versa. The study was able to identify that the glass-coat of yellow glass-coat coloration has the highest pH value of 8.62 and the blue glass-coat coloration has the lowest pH value of 8.30, though this might make the coating prone to some level of degradation that is highly negligible in the long run. In comparison with other study such as Ogu *et al*, (2016), CropLife (2018) and Ndibe *et al.* (2021), the developed coat pH value falls within the acceptable standard of 7.0–9.0 pH thereby making it durable for application in buildings.

Table 2: pH test on produced glass-coat

Coat colour	Yellow	Blue	Red	Black
pH value	8.62	8.30	8.42	8.50

Chemical Resistance Test

The results of the analysis in Table 3 show the behaviour of the produced glass-coat and its resistance to acidic and alkaline conditions when applied to building surfaces. The results show that the developed glass-coat generally exhibits resistance to chemical attack based on its general percentage behaviour to the acidic and alkaline solution and the investigated defects i.e., blistering, peeling, lifting, crazing, flaking, and discoloration (Akinterinwa *et al*., 2015). However, some chemical alkaline solutions such as sodium hydroxide (NaOH), magnesium hydroxide (Mg(OH)2), potassium hydroxide, and an acidic solution of hydrofluoric (HF) acid had some effect on the glass coating. The effects range from flaking and discoloration to a defect rate of not more than 10%. It was also observed that there was a slight reduction in the weight of the coating on reaction with NaOH. As such, the polymeric component of the coating is slightly prone to degradation when exposed to NaOH solutions or environments (Ndibe *et al*., 2021).

Table 3: Results of acid and alkali resistance tests on produced glass-coat

Chemical	Blistering %	Peeling %	Lifting %	Crazing %	Flaking %	Discoloration %
			Acid			
HF	0	0	0	0	0	5
HCl	0	0	0	0	0	0
H_2SO_4	0	0	0	0	0	0
HHO_3	0	0	0	0	0	0
			Alkali			
KOH	0	0	0	0	0	7
NaOH	0	0	0	0	5	10
$Ca(OH)_2$	0	0	0	0	0	0
$Mg(OH)_2$	0	0	0	0	0	3

Abrasion Test

The result in Table 4 shows the abrasion rate of the developed glass coating on application to the substrate. This analysis is needed for this study so as to ascertain the level of degradation caused by exposure to acidic and alkaline conditions, considering its composition (largely composed of coarse aggregate) and type of developed coat (textured coat). This analysis was able to establish that the developed coat is prone to abrasion. However, the coating under a load of 3.5 kg in 60 cycles manifests an abrasion rate of 0.2 g, irrespective of the coat's colour, with negligible physical damage to the surface of the coat. In comparison with the standard (4g ± 0.5g), it was observed that there is a weak chemical attack on the coat such that it was unable to degrade the coating by abrasion leading to a negligible abrasion rate when compared to the standard abrasion rate of 4 ± 0.5g as approved by *ASTM D4060* (2019).

Table 4: Abrasion test of the produced glass-coat

Coat type	Weight of coated plate before test (g)	Weight of coated plate after test (g)	Abrasion rate (g)
Black	54.30	54.10	**0.20**
Red	54.30	54.10	**0.20**
Blue	54.30	54.10	**0.20**
Yellow	54.30	54.10	**0.20**

CONCLUSION

In conclusion, the study established that the developed glass-coat has a 4A adhesion rate, a pH range (8.30 - 8.62), a negligible chemical degradation rate (3-10%), and an abrasion rate (0.2g) that conforms to standard (ASTM D3359), (ASTM D5464), (ASTM D4060 ASTM D3260 and ASTM D1308). Findings shows that the developed glass-coat exhibits an excellent pH and a 4A adhesion rate which confirmed the negligible abrasion rate and the weak chemical degradation that is not above 10% regardless of the nature of the chemical solution (acidic or base). Owing to the analysis conducted, this study recommends that the glass-coat developed from recycled PCG is suitable for interior and exterior application most especially in environment that is pose to chemical degradation.

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