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Sustainability and Suitability of Polycarbonate in Public Building: An Overview

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ABSTRACT

Sustainable building is an environmental approach to the creation of new structures as well as remodeling existing once; hence, the concept of green buildings. Green buildings seek to make the best use of materials that are sustainable or that are renewable in nature. The attempt to reduce the collective environmental impact during production of building components, during the construction process as well as during the life cycle of the building: hearting, electricity, use etc. motivated this work. The purpose is to highlight the material importance, its suitability and applications in public buildings.

Keyword: Polycarbonate, Sustainability Architecture and Green Material

Introduction

Polycarbonate is a strong synthetic resin material used to manufacture molded products, optical components and unbreakable windows. With the exception of the last component, it is obvious that this material is not predominantly meant for design and construction (Bello 2011). However, this synthetic resin material which has polymer units linked through carbonate group has a lot to offer in the field of architecture. It offers a new concept in architectural glazing, providing outstanding performance and flexibility in design (Encarta 2009). The polycarbonate material is translucent in nature. Thus, it proclaims itself quite unambiguously as a useful material in architectural lighting design, which important aspect in life and buildings cannot be ignored.

MATERIALS AND ACRCHITECTURE

Over the years, materials dominance in buildings has been witnessed, just like in all other areas of discipline. Architecture consists basically of man's attempts at changing his environment according to his functional, biological and psychological needs (Amekwu2008). It is therefore, accustomed to experiencing vast changes especially with regards to materials, styles, concepts and techniques. These changes make it imperative to examine, appraise and unleash new materials in to the building industry that is not only sustainable but environmentally friendly. Polycarbonates are materials that have various qualities and applications when used in buildings, many stakeholders in the design and construction industry seem to be oblivious of the merits that the fabric has and past it for lack lustre and awkward materials. There is need to highlight on these merits, attributes and accolades enough to draw the attention of all in the building industry.

Glazing, partitioning and shading, are well known and extremely useful elements of architecture. Few materials dominated these aspects. Polycarbonates unfortunately, are rarely found among these materials despite possessing rare qualities such as; energy efficiency, thermal insulation, good fire performance, damage resistant and durability.

THEORETICAL FRAMEWORK

History of the Polycabonates

Polycarbonate is derived from BPA (bisphenol A) and was discovered in 1953 by Bayer and at General electric. It was first introduced in the market in 1958 by Mayer Mobey and General electric. www.plasticseurope.com confirmed that, it was discovered by Dr. H. Schnell at Bayer A.G. Germany and D.W fox at general electric company USA. Polycarbonates received their names because they are polymers containing carbonate group. (-O-(C=0)-0-). Most polycarbonates of commercial interest are derived from rigid monomers. A balance of useful feature including temperature resistance, impact resistance and optical properties positioned polycarbonate between commodity plastic and engineering plastic. It was initially used for electrical and electronic appliances, fuse

boxes, displays and plug connections and subsequently as glazing for green houses. Soon this material's outstanding combination of beneficial characteristics made it the material of choice for many other applications including public buildings. www.wikepedia.com affirmed that the second largest consumer of polycarbonate in Europe and America is the construction industry.

CHEMISTRY OFPOLYCABONATE

The main polycarbonate material is produced by reaction of beisphenol A and Phosgene COC_{12}. The overall reaction can be written as follows:

The first step of the synthesis involved, treatment of beisphenol A with sodium hydroxide which deprotonates the hydroxyl groups of the bisphenol A

$(HOC_6H_4)\ 2CMe_2 + 2NcOH\ (NaOC_6H_4)2Cme_2 + 2H_20$

The diphenoxide $(NaOC^6H^4)2Cme^2$ reacts with phosgene to give a chloropomate, which subsequently is attacked by another phenoxide. The net reaction from diphenoxide is:

$(NaOC_6H_4)2Cme_2 + COCL_21/n[OC\ (0C_6H_4)2Cme_2] + 2Nacl$

In this way, approximately one billion kilograms of polycarbonate is produced annually. Many other diols have been tested in place of beisphenol A, e.g. 1-1bis (4-hydroxyphenyl) cyclohexane and dihycloxybenzaphenone. The cyclohexane is used as a co-monomer to suppress crystallization tendency of BPA- derived products. Tetrapromobisphenol A is used to enhanced fire resistance, while Tetramythyle-cyclobutanediol as a replacement for BPA.

An alternative route to polycarbonate entails Trans-esterification from BPA and diphenyl carbonate

$(NaOC_6H_4)2Cme_2 + COCL_2{}^1/n\ [OC\ (0C6H^4)2Cme^2]\ n + 2C^6H^50H$

The diphenyl carbonate was derived in part from carbon monoxide and proved greener than phosgene method.

PROPERTIES OF POLYCARBONATES

Though polycarbonate has high impact resistance, it has low scratch resistance; a hard coating is applied to polycarbonate eyewear lenses and polycabornate exterior automotive components. The properties of polycarbonate are quite like those of polymelthyl methacrylate (PMMA, acrylic); but polycarbonate are stronger and usable in a wider temperature ranges and it is highly transparent to visible light. www.bayermaterialsciencenafta.com established that, polycarbonate has a glass transition temperature of about 147°C and it soften gradually above this point and flows at above 155 °C. Polycarbonate like precast concrete is produced in various grades for various purposes. The low molecular mass grades are easier to mould than higher grades, but their strength is lower as a result. The toughest grades have higher molecular mass and are much more difficult to process. Unlike most thermoplastics, polycarbonate can undergo large plastic deformation without cracking or breaking. It can be produced and formed in room temperature using sheet metals; this makes it valuable for prototyping applications where transparent or electrically non-conductive parts are needed which cannot be obtained from the sheet of metal (www. Cityplasctic.com).

Main transformation of polycarbonate resins include:

- Extrusion into tubes, rods and others profiles
- Extrusion with cylinders into sheets and which can be used directly or manufactured into other shapes using thermoforming or secondary fabrication techniques such as bending, drilling, routing, lesser cutting etc.
- Injection moulding into ready panels

PROPERTIES

Mechanical Properties	Test Method	English	Metric
Tensile Strength (Type 1, 0. 125"/min)	ASTM D638	9,800PSI	68MPa
Tensile Modulus (Type 1, 0,125"/min)	ASTM D638	330, 000 psi	2, 300 MPa
Tensile Elongation (type 1, 0, 125", 0.2"/min)	ASTM D638	5%	5%
Flexural Strength (Method 1,0.005"/min)	ASTM D790	15,100 psi	104
Flexural Strength Method 1, 0.05" /min)	ASTM D790	324, 000 Psi	2,200
IZOD Impact, notched (method A, 23^0 C)	ASTM D256	1 ft – Lb/in	53 J/m
IZOD Impact, un-notched Method A, 23 23^0 C)	ASTM D256	6 ft-ib/in	320J/m
Thermal Properties [2]	**Test Method**	**English**	**Metric**
Heat Deflection (HDT) @ 66 psi	ASTM D648	280^0f	138^0C
Vicat Softening	ASTM D1525	282^{-0}F	139^{0C}
Glass Transition (Tg)	DMA (SSYS)	322^0f	161^0C
Melt Point	_ _ _ __	Not Applicable	Not Applicable[3]

Electrical Properties	Test Method	Value Range
Volume Resistivity	ASTM D257-98	2.0x10e14- 6.0X10e 13 ohms
Dielectric Constant	ASTM D150-98	3.0 – 2.8
Dissipation Factor	ASTM D150-98	.0006 -0005
Dielectric Strength	ASTM D149 -09. Method A	360-80 V/mm

Source: www.fortus.com

Dampalon (2012) confirmed that, the material saves a lot of energy as it reduces the need for artificial lighting and it offers more thermal and sound insulation than any other day lighting system. Another interesting property of this material is its high impact resistance which can be more than 200 times greater than tempered glass. Its panel is

extremely weather resistant, its sheet can be as clear as glass, translucent or completely opaque depending on the specific use. The panel can be flat or flexible, thin or thick, there are glazing grades that provide static control and fire resistance as well as sign grade for bullet proof resistance, hurricane resistant etc. www.wisegeek.com opines that sheet from polycarbonate is a very suitable material for public buildings that can replace glass in a variety of applications.

MERITS OF POLYCARBONATES

According to www.wisegeck.com, polycarbonate is versatile, tough plastic used for variety of applications from bullet proof windows to compact disk (CD's). The main advantage of this material over other types of plastic is unbeatable strength combined with light weight. While acrylic is 17% stronger than glass, polycarbonate is just one-third the weight of acrylic or one-sixth as heavy as glass. In the field of design and construction, polycarbonate is a multipurpose and utility material. Being versatile, it is ultraviolet and heat resistant (www.qalina.com). Most apparent quality that this material possesses is its translucency, thus, making it suitable for building facades, roof light and internal partition in public and commercial buildings.

POLYCARBONATE AND ITS IMPACT ON THE ENVIRONMENT

The foregone chemical reaction revealed that the diphenyl carbonate is derived from carbon monoxide which made the route greener than the phosgene method. According to www.pasticseurope.com emissions to the environment from the production of polycarbonate are extremely very low, because it is produced in a closed process with careful emissions practices. This reduction in emission and many more of its qualities qualifies it to occupy position in the 21st century's concept of sustainable material for the built environment, often called green material. Accordingly, sustainable architecture always attempts to reduce the collective environmental impact during the production of building components, during the construction process as well as during the life cycle of the building; heating, electricity use etc. (JI Yan, and Painiotis 2006). In addition, Maibe (2010) asserts that, sustainable building is an environmental approach

to the creation of new structures as well as remodeling existing ones; hence he continued stating that the concept of green building seeks to make the best use of materials that are sustainable or that are renewable in nature. Green buildings are constructed in a way that minimizes environmental impact using less environmentally damaging materials and techniques (Adeleke 2008).

CONCLUSION

Polycarbonate has proven to be extremely versatile as it resists natural disaster and most interestingly it cannot disintegrate from impact owing to its properties. Environmentally, the products are found to be very friendly and very suitable for different applications in the construction industry, it can be suitably applied in a number of places owing to its qualities: public buildings, commercial and financial institutions. While it proved its strength and suitability, it is a recyclable and environmentally energy efficient material thus, qualifying it to be a green building material; as Green building is no more than combining the imaginative use of modern technology with sustainability, which can pay for them and not necessarily more expensive to construct to lead to enhanced satisfaction by users.

…….in a resource-dependent world, buildings provide a tremendous
Opportunity to mitigate the impact of the built environment on water,
Energy and carbon emissions…….. (Mc Graw Hill Construction 2008)

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