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ELIMINATION OF PLASTICIZED POLY(VINYL CHLORIDE) DEGRADABILITY BY USING OXYDTRON: A NOVEL STUDY

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ABSTRACT

There is no supernatural material in the universe, but there is a material can be having more than one characteristic that makes it unconventional and this which was discovered in this study. Based on the poly(vinyl chloride) heat stability measurements which obtained by dehydrochlorination test, it has been shown that Oxydtron is not only a material used to improve the properties of concrete; but also a material that has shown a significant indications in the stabilization process of plasticized poly(vinyl chloride). Where the rate of degradation of poly (vinyl chloride) was effectively decreased after adding Oxydtron, which means the Oxydtron act as an effective stabilizer for plasticized poly (vinyl chloride).

Keywords: plasticized poly (vinyl chloride), oxydtron, dehydrochlorination, degradation.

INTRODUCTION

It is known to everyone that one of the main disadvantages of poly(vinyl chloride) despite the many advantages which is the release of chlorine containing compounds (such as HCl) from its internal structure after exposure to high temperatures as shown in Figure-1, and this process is called dehydrochlorination, and when poly(vinyl chloride) reaches this stage, it actually begins to degrade, which is dangerous not only because it has started to lose its properties, but because degradation products "chlorine compounds" are toxic, which is a danger to human health and leads to environmental pollution although the poly(vinyl chloride) fires are not so huge to consider as an environmental disaster but it is a danger that can't be overlooked. In order to treat this problem, many types of fillers or additives are added to increase the efficiency of the poly(vinyl chloride) to resist flammability, which is reflected positively on making its internal structure, is more stable at elevated temperatures, which raises resistance against the release of chlorine [1-7]. On the other hand, unfortunately, many of conventional stabilizers contain heavy elements that are harmful to the environment, although they increase the efficiency of the performance of poly (vinyl chloride) at high temperatures and make its structure more stable. So it must (as much as possible) that these stabilizers and other additives are environmentally friendly and at the same time have the ability to improve the thermal resistance of the poly (vinyl chloride) [8-10].

Therefore, this research introduces a new material which is Oxydtron that does not contain heavy metals and at the same time an excellent stabilizer for poly (vinyl chloride). The unexpected behavior of Oxydtron as a stabilizer qualifies it to be a substitute or at least a competitor to existing stabilizers. Oxydtron was originally developed for using as additives with Portland cement in order to improve the properties of cement. The Oxydtron is not a nano particles additives where it is a micro particles additives and only the modifier particle's coating layer is nano size from 10-100 nm particles range; and this nano layer which give the characteristic properties for Oxydtron. Oxydtron mixture contain many materials, most of which are oxides and carbonates with high melting points [11, 14].

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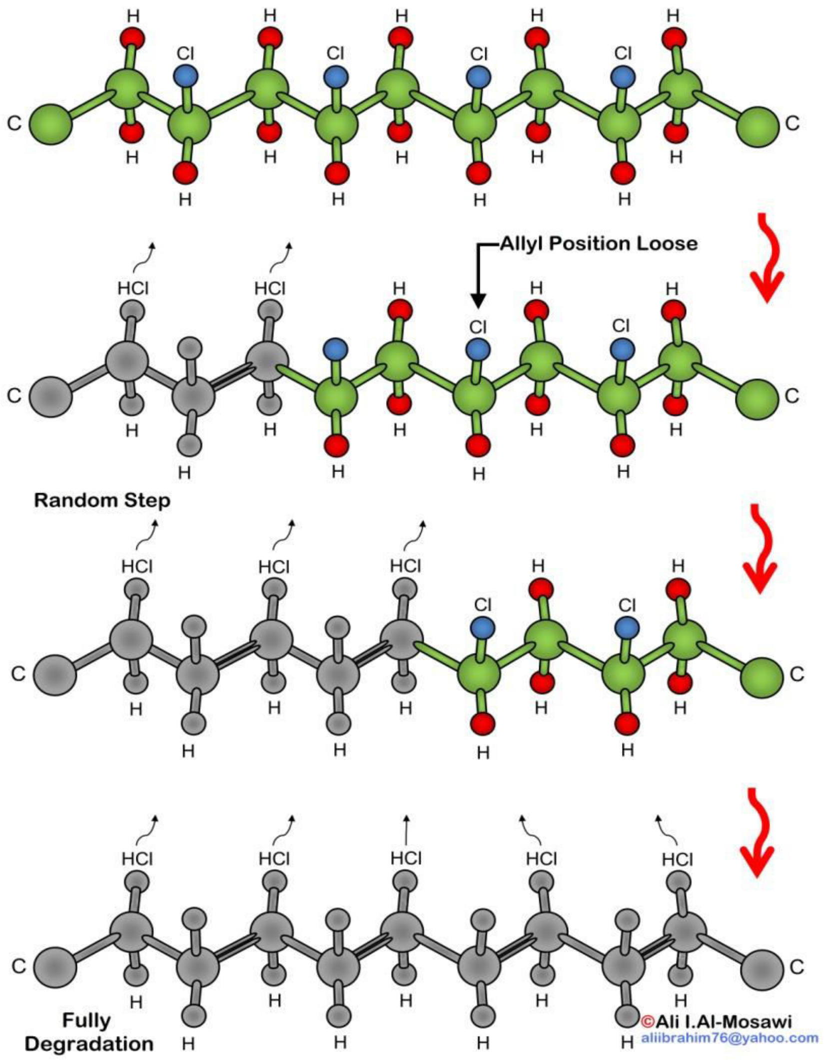

Figure-1. Mechanism of Degradation for PVC.

METHODOLOGY

a. Materials

The raw materials used for producing tests samples illustrated in Table-1 which can be described as follows: (1) PVC S-5070 powder (under trademark Ongrovil®) which produced and supplied by BorsodChem Zrt., Hungary; (2) the plasticizer DOP (Di-Octyl Phthalate) supplied by DEZA, a. s. CO., Valašské Meziříčí, Czech Republic; (3) Calcium-Zinc based stabilizer (under trademark Newstab-50) which supplied by Betaquímica CO., Barcelona, Spain; (4) the lubricant Wax-E (under trademark Licowax®E) supplied by Clariant International Ltd, Muttenz Switzerland; and (5) Oxydtron type A supplied by Bioekotech Hungary Kft.

Table-1. Materials used and their percentages.

Component	PVC basic formulation	PVC modifier formulation
Poly(vinyl chloride) (PVC S-5070)	100	100
Di-Octyl Phthalate (DOP)	70	70
Calcium-Zinc stabilizer (Newstab-50)	1.5	1.5
Lubricant Wax-E	0.3	0.3
Oxydtron (wt.%)	-	1, 3, 5

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b. Materials processing

poly(vinyl chloride) basic formulation components shown in Table-2 were mixed by using mechanical mixer type MTI 10 Mischtechnik at 150°C; in order to ensure homogeneity of the mixture and all samples will get the same composition and characteristics after fabricating. After the main mixing process, the Oxydtron is added with the weight fraction (0-5 wt.%). The new mixture has been mixed by small electric mixer for obtain a homogeneous distribution of Oxydtron additives within poly (vinyl chloride) powder.

c. Samples fabrication and tests

The samples were fabricated by an extrusion machine type SCHLOEMANN as a particles of poly (vinyl chloride) and Oxydtron wt.% additives with 3 mm diameter and 2 mm thickness. Dehydrochlorination test has been done at 180 ºC and according to ISO 182-3:1993 standard [15] by Metrohm 763 Thermomat device found at BorsodChem Zrt., Hungary. Scanning electron microscopy SEM was used for chemical composition and structure analysis of Oxydtron as shown in Figure-2. This test was done by using Carl Zeiss EVO MA10 SEM at Institute of Physical Metallurgy, Metal Forming and Nanotechnology, University of Miskolc, Hungary. Also, ICP-AES spectrometer, made by Varian Inc. was used for analysing of Oxydtron compounds. ICP-AES spectrometer found at Institute of Chemistry, University of Miskolc, Hungary.

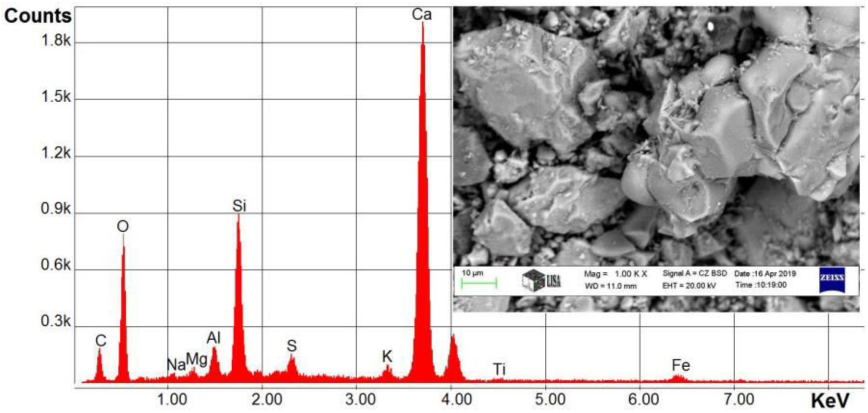

Figure-2. SEM-energy dispersive X-ray microanalysis for Oxydtron.

Table-2. The approximate chemical composition of Oxydtron (expressed as oxides) by ICP-AES method, in wt.%.

Oxides	Ratio, wt.%
Al_2O_3	4.47
CaO	58.0
Cr_2O_3	0.006
Fe_2O_3	2.67
K_2O	0.78
MgO	1.20
Mn_2O_3	0.05
Na_2O	0.31
SO_3	2.50
SiO_2	21.44
TiO_2	0.274
ZnO	0.138

RESULTS AND DISCUSSIONS

When the temperature rises, the crystalline structure of poly (vinyl chloride) becomes less stable, leading to the release of chlorine containing compounds and as a result, the resistance of poly (vinyl chloride) starts to decrease and this is clear at Figure-3, which represents the dehydrochlorination behavior for poly (vinyl chloride) at 180°C. From this figure we can see that the curve has high inclination (slope is very sharp) which is an indication that the poly (vinyl chloride) releases chlorine containing compounds rapidly and roughly because the low thermal resistance of poly (vinyl chloride) which leads to the full degradation of poly (vinyl chloride) [16]. This behavior of poly(vinyl chloride) will be changed after adding Oxydtron additives, where The crystalline structure of poly(vinyl chloride) show more stable at high temperatures as shown in Figure-4 which represents the dehydrochlorination test for plasticised poly(vinyl chloride) after adding 1% Oxydtron addition. The slope of the curve had been decreased from (0.000246) for poly(vinyl chloride) basic formulation (Figure-3) to (0.000176) after Oxydtron addition; which means the poly(vinyl chloride) structure becomes more stable and the tendency to release containing compounds has been decreased and the period of degradation extended from (1.144 hour) before adding Oxydtron to (1.983 hour) after Oxydtron additions. The resistance to degradation has been increased as Oxydtron addition percentage increasing, as shown in Figure-5 and Figure-6 which represent the dehydrochlorination behavior of plasticised PVC with 3% and 5% Oxydtron additions respectively. It is clear from these two figures that the curve tends to rise gradually with a low slope, which means that the rate of

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degradation has decreased, where we can see that the slope of the curve becames (0.000163) at 3% Oxydtron addition and the degradation time extended to (2.133 hours). And with 5% Oxydtron addition the the slope of the curve is (0.000142) and the degradation time was extended to (2.144 hours). Slopes values illustrated in Table-3. So, the optimum improvement of degradation period obtained by 5% Oxydtron addition was 73.24% longer than poly(vinyl chloride) basic formulation.

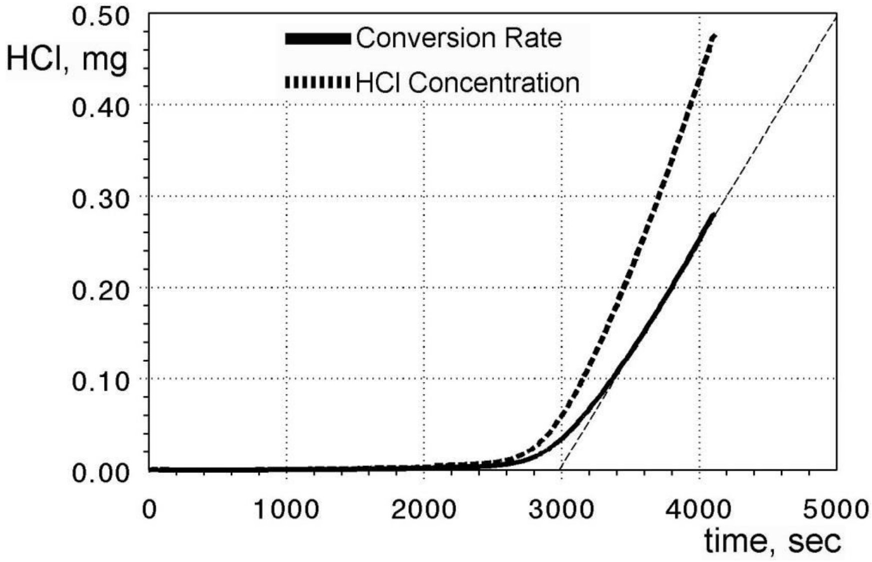

Figure-3. Dehydrochlorination method test (thermostability) at 180°C for plasticised poly(vinyl chloride) basic formulation.

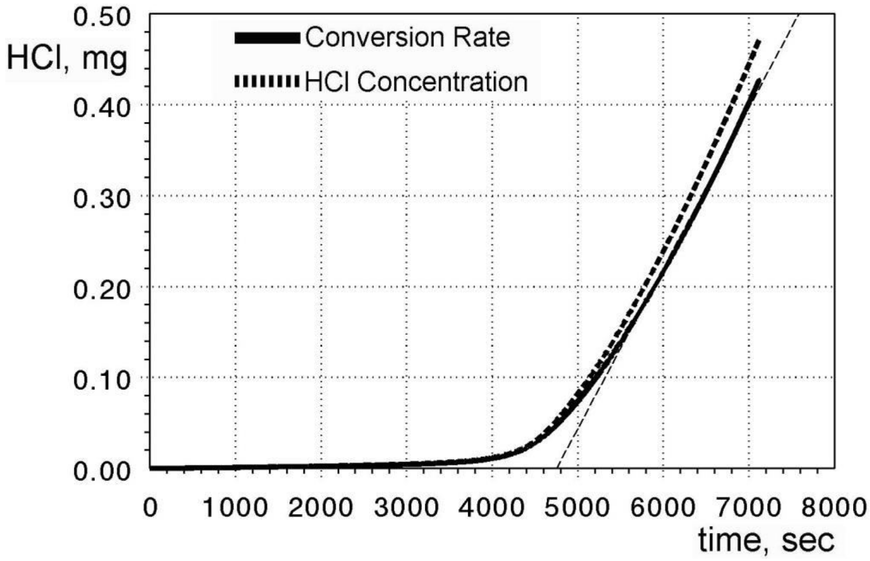

Figure-4. Dehydrochlorination method test (thermostability) at 180°C for plasticised poly(vinyl chloride) containing 1% Oxydtron.

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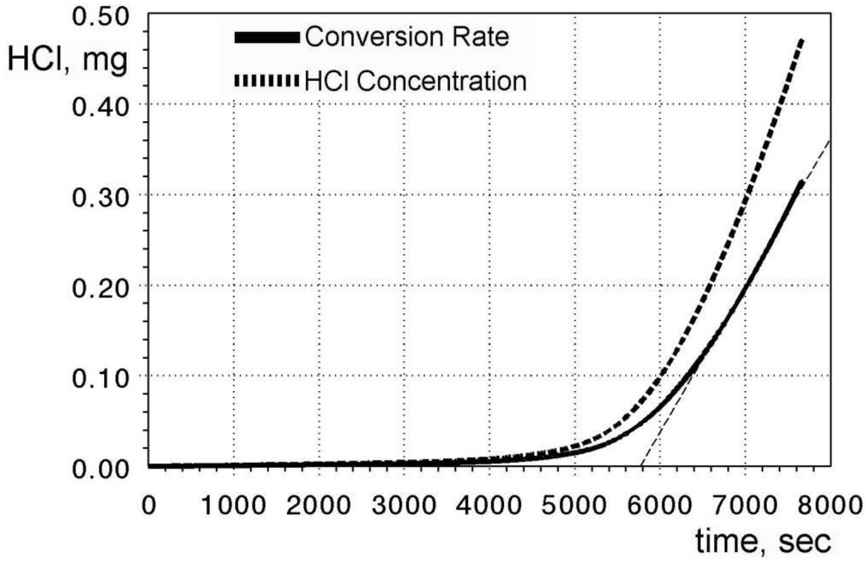

Figure-5. Dehydrochlorination method test (thermostability) at 180°C for plasticised poly(vinyl chloride) containing 3% Oxydtron.

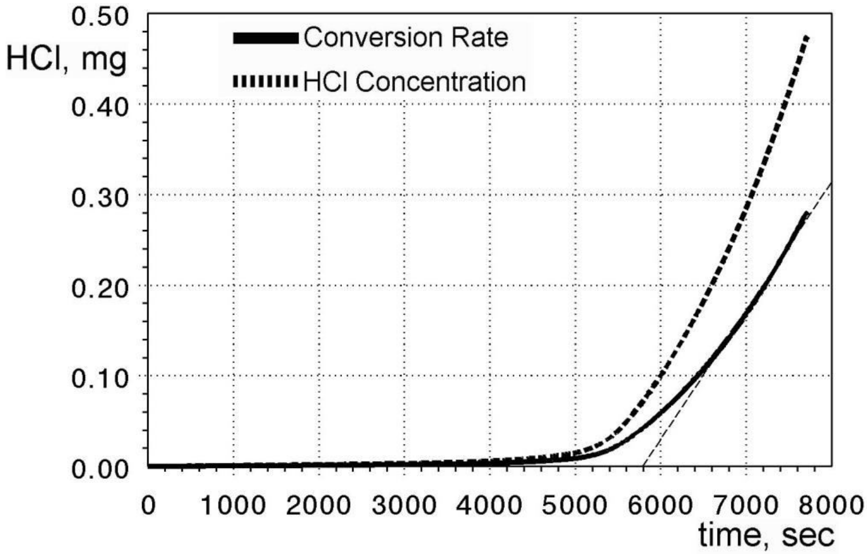

Figure-6. Dehydrochlorination method test (thermostability) at 180°C for plasticised poly(vinyl chloride) containing 5% Oxydtron.

Table-3. Slopes values of dehydrochlorination test.

Material	Slope, %s-1	DHC time, hour
PVC	0.000246	1.144
PVC + 1% Oxydtron	0.000176	1.983
PVC + 3% Oxydtron	0.000163	2.133
PVC + 5% Oxydtron	0.000142	2.144

CONCLUSIONS

Using of Oxydtron for the first time as a poly(vinyl chloride) stabilizer with highly efficient for thermal stabilizing and this was unexpected behavior of a material used as cement additive for construction purposes only and the results obtained not found in literatures before. The degradation rate of plasticised poly(vinyl chloride) was improved by Oxydtron additives and the optimum time required for full PVC degradation was 87.4% longer than poly(vinyl chloride) basic formulation obtained by 5% Oxydtron addition.

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