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EVALUATION OF OXODEGRADABLE MATERIALS: UV TESTING OF A POLYPROPYLENE MATERIAL

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EVALUATION OF OXODEGRADABLE MATERIALS:

UV TESTING OF A POLYPROPYLENE MATERIAL

1. INTRODUCTION

A polypropylene film labelled d2w containing oxo-degradable masterbatch 93114 was supplied for UV degradation tests. The film was received on the 15th February 2006.

Tensile strength, modulus, elongation at break and carbonyl index values of aged and un-aged samples have been determined to examine the degree of degradation with length of exposure to UV radiation.

2. CONCLUSIONS

Data obtained has demonstrated that the presence of the 93114 masterbatch has speeded up the degradation of the polypropylene material when exposed to UV radiation. Significant degradation/embrittlement occurred after 1- 2 days exposure. Results obtained are given in Section 4 of this report.

3. EXPERIMENTAL

Upon receipt, the sample was conditioned at $23 \pm 2^{\circ}\text{C}$, $50 \pm 5\%$ relative humidity for at least 88 hours prior to testing.

3.1 UV ageing study

The sample was exposed to ultra-violet radiation in a QUV apparatus as per ASTM D5208 (2001) fluorescent ultraviolet (UV) exposure of photodegradable plastics. Cycle C was employed (Continuous UV with uninsulated black panel temperature controlled at $50 \pm 3^{\circ}\text{C}$). Five 15 mm wide tensile strips and one carbonyl index sample were cut from the film for each ageing period. After measuring, the strips were mounted and transferred to a QUV weathering machine. The UV exposure was performed using UVA 340 lamps.

After 1, 2, 3, 5, 7 and 9 Days, the tensile and carbonyl samples were removed from the QUV, allowed to return to room temperature, and their tensile properties determined in comparison with non-aged materials.

The carbonyl index of the UV aged samples (examining the degree of oxidation) was determined by infrared spectroscopy. Reflection spectra of the surface of the films were obtained using a Specac Golden Gate attachment connected to a Nicolet FTIR spectrometer. The carbonyl index was determined as the ratio of the carbonyl absorption at 1718cm⁻¹ with the (carbon-hydrogen) absorption at 2920cm⁻¹

4. RESULTS

4.1 Physical tests

The UV exposure test had a degradation effect on the Polypropylene d₂w film after 1 day. The tensile samples became very brittle and too weak to test after 3 days exposure. Results obtained were as follows;

Test No.	PP Film d ₂ w - Unaged				
	Modulus at 50% (MPa)	Tensile Strength at Peak (MPa)	Elongation at Peak (%)	Tensile Strength at Break (MPa)	Elongation at Break (%)
1	13.7	18.5	6.7	6.72	230
2	13.2	21.9	390		>400
3	13.4	21.4	3.0		>400
4		19.4	8.4	6.07	38
5	13.0	18.9	9.6	7.47	76
Mean	<u>13.3</u>	<u>20.0</u>	<u>84</u>	<u>>6.76</u>	<u>>220</u>
σ _{n-1}	0.29	1.53	173		

Samples 2 and 3 did not break within the maximum displacement of the machine.

Test No.	PP Film d ₂ w – 1 Day UV Exposure				
	Modulus at 50% (MPa)	Tensile Strength at Peak (MPa)	Elongation at Peak (%)	Tensile Strength at Break (MPa)	Elongation at Break (%)
1		19.3	7.3	17.8	8.2
2		20.7	8.9	19.0	11
3		19.6	5.0	17.8	5.6
4		19.6	6.5	17.7	7.3
5		19.6	6.6	18.3	7.3
Mean		<u>19.8</u>	<u>6.9</u>	<u>18.1</u>	<u>8.0</u>
σ_{n-1}		0.55	1.42	0.54	2.15

All samples broke outside the gauge length.

Test No.	PP Film d ₂ w – 2 Days UV Exposure				
	Modulus at 50% (MPa)	Tensile Strength at Peak (MPa)	Elongation at Peak (%)	Tensile Strength at Break (MPa)	Elongation at Break (%)
1		8.32			
2		6.69			
3		12.4			
4		11.6			
5		8.44			
Mean		<u>9.48</u>			
σ_{n-1}		2.40			

Samples broke in the grips and the extensometer lost the reflective marks.

Three, five, seven and nine day samples were also too weak to test.

Dates of Test: 3rd to 15th March 2006.

4.2 Carbonyl index

Carbonyl index data were as follows. Carbonyl index values above 0.1 are highlighted in bold (sometimes taken as the embrittlement time). The data are shown graphically in Figure 1.

Sample	Carbonyl Absorption	Carbon Hydrogen Absorption	Carbonyl Index
D2W Unexposed	0.003	0.29	0.010
D2W 3 Days QUV	0.009	0.281	0.032
D2W 5 Days QUV	0.029	0.188	0.154
D2W 7 Days QUV	0.052	0.236	0.220
D2W 9 Days QUV	0.040	0.118	0.339

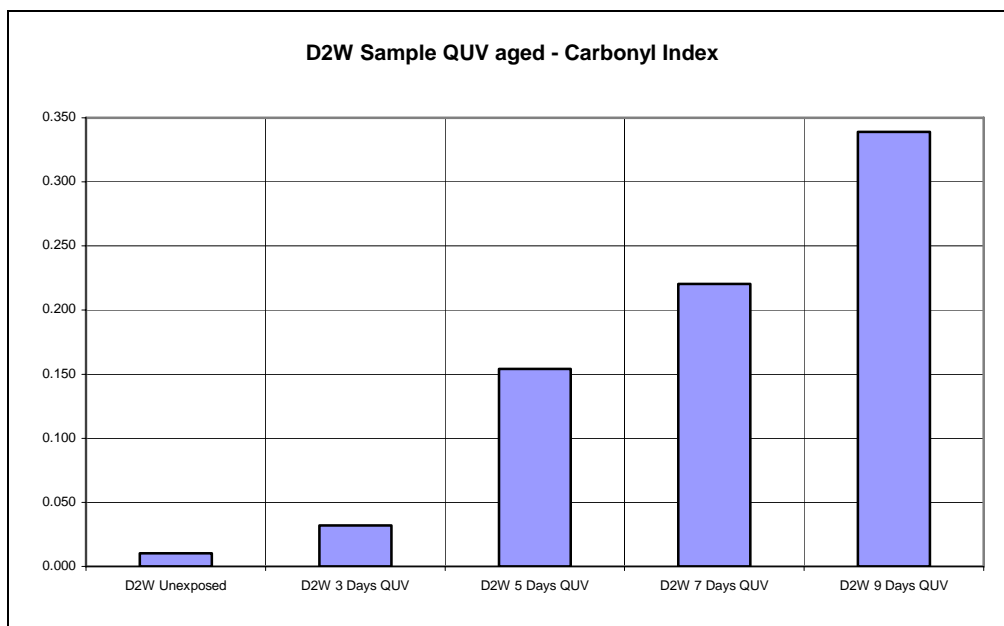


Figure 1

**RAPRA TECHNOLOGY UNITED KINGDOM
CONDITIONS OF BUSINESS**

FORMATION OF CONTRACT

- 1.1 All quotations are made and all orders are accepted subject to the following conditions. All other terms, conditions or warranties whatsoever are excluded from any contract between the parties unless expressly accepted by Rapra Technology ("Rapra") in writing.
- 1.2 Quotations shall be available for acceptance for a maximum period of 30 days from the dates thereof and may be withdrawn by Rapra within such period at any time by written or oral notice. "Work" shall mean the work and services that Rapra agree to provide in the quotation.
- 1.3 If any statement or representation has been made to the Client by Rapra, or its employees upon which the Client relies (other than in the documents enclosed with Rapra's quotation) then the Client must set out that statement or representation in a document to be attached to the return copy of the quotation and in any such case Rapra may accept or reject the same and/or submit a new quotation.
- 1.4 The supply of materials, products or information by the Client pursuant to the quotation shall constitute acceptance of these conditions where acceptance has not previously been communicated by the Client to Rapra.

PRICES

- 2.1 All prices are, unless otherwise stated, quoted net exclusive of VAT.
- 2.2 All requests for variations or addition to the Work must be made by the Client in writing. In the event of any variation or addition being so requested and agreed to by Rapra, Rapra shall be entitled to make an adjustment to the contract price fairly reflecting such variation or addition.

PAYMENT

- 3.1 Unless otherwise agreed by Rapra in writing the terms of payment shall be 30 days from receipt of invoice by the Client, which shall be deemed to be two working days after posting. Rapra may submit interim invoices in respect of each stage of Work completed for the Client.
- 3.2 No disputes arising under the contract nor delays beyond the reasonable control of Rapra shall interfere with prompt payment in full by the Client.
- 3.3 In the event of default in payment by the Client Rapra shall be entitled at its option to treat the whole contract as repudiated by the Client or to suspend all further work on any contract or contracts between Rapra and the Client without notice and to charge interest on any amount outstanding at the rate of 2% per annum above the Base Rate of National Westminster Bank plc in force at the time when payment was due.

COMPLETION

- 4.1 Time for completion of Work is given as accurately as possible but is not guaranteed. The Client shall have no right to damages or to cancel the order for failure for any cause to meet any time stated for completion of Work.
- 4.2 Any estimate of the date of completion of Work shall in every case be dependent upon prompt receipt of all necessary information, instructions or approvals from the Client. Variations or additions to the Work requested by the Client may result in delay in completion.

CANCELLATION

5. Either party may cancel the contract on 30 days written notice to the other on condition that all costs and expenses incurred by Rapra up to the time of cancellation and, where cancellation is at the insistence of the Client, all loss of profits and other loss or damage resulting to Rapra by reason of such cancellation, will be paid forthwith by the Client to Rapra.

LIABILITY

- 6.1 Rapra undertakes that it will indemnify and keep the Client indemnified against all liabilities, costs and expenses in respect of claims in relation to death or injury to persons or damage to tangible property to the extent that such death, injury, loss or damage is attributable to the negligent acts or omissions of Rapra, its officers, employees, agents or sub-contractors.
- 6.2 Save where Rapra is shown to have failed to exercise reasonable care in the performance of the Work and such failure results in death or personal injury, Rapra shall not be liable in respect of claims arising by reason of death or personal injury. Further, under no circumstances whatsoever shall Rapra be liable for consequential loss, loss of profits, damage to property or wasted expenditure.
- 6.3 Rapra's liability, whether in respect of one claim or the aggregate of various claims other than claims for death or personal injury due to negligence on the part of Rapra shall not exceed £500,000 in any Year and the Client agrees to insure adequately to cover claims in excess of such amount.

CONFIDENTIAL INFORMATION AND INDUSTRIAL PROPERTY RIGHTS

- 7.1 All data, information and reports are produced for the benefit of the addressee only. Rapra accepts no liability arising from unauthorised use of such information or reports by a third party.
- 7.2 The Client shall not reproduce or abstract for the purpose of advertising or otherwise any report or other information on the Work or use the name of Rapra either expressly or by implication in any of its advertising or sales promotional material without the prior written consent of the Company Secretary of Rapra.
- 7.3 All drawings, documents, confidential records, computer software and other information supplied by Rapra are supplied on the express understanding that copyright is reserved to Rapra and that the Client will not, without the written consent of Rapra, either give away, loan, exhibit or sell any such drawings, documents, records, software or other information or extracts therefrom or copies thereof or use them in any way except in connection with the Work in respect of which they are issued.
- 7.4 All Intellectual Property Rights belonging to or otherwise in the control of either party prior to entering into the contract shall remain the property of the party owning such Intellectual Property Rights.
- 7.5 All title and ownership of, or relating to, any intellectual property, including, but not limited to ideas, inventions, discoveries, creations, improvements or any other property subject to patent protection or intellectual property rights as developed or resulting from work under this agreement, shall directly or indirectly be solely owned by Rapra Technology Ltd, unless otherwise agreed to in writing by all participating parties.
- 7.6 In the event that Rapra Technology Ltd does not wish to apply for or maintain patent protection for any invention owned by it in accordance with clause 7 herein, it will on request assign its rights in respect of that patent to the client but in any event Rapra Technology Ltd shall be granted a royalty free, irrevocable, non-exclusive, world-wide right to use such intellectual Property Rights assigned under this condition 7.6.
- 7.7 Rapra Technology Ltd will on request grant rights to the client for exploitation or patenting of the ideas, inventions, discoveries, creations, improvements arising from the work, in the client's traditional or defined new areas of business. In all other areas, rights remain vested with Rapra Technology Ltd.

SAMPLES

8. Rapra retains the right to return or dispose of the samples at the customers cost after a period of 6 months unless otherwise agreed with the client. Storage of the samples beyond the initial 6 month period will be charged for, invoiced in advance for the agreed period (minimum additional 6 months).

CUSTOMER'S INFORMATION

- 9.1 The Client shall be solely responsible for ensuring that all drawings, information, advice and recommendations given to Rapra, either directly or indirectly by the Client or by the Client's agents, servants, consultants or advisers, are accurate and sufficient for completion of the Work. Examination or consideration by Rapra of such drawings, information, advice or recommendations shall in no way limit the Client's responsibility hereunder unless Rapra specifically agrees in writing to accept responsibility.
- 9.2 Rapra shall not disclose to any third party any knowledge or information relating to the Work which is, on receipt by Rapra, marked 'confidential' by the Client unless and until such information becomes public knowledge.

INSOLVENCY

10. If either party shall become bankrupt or under the provisions of Section 123 of the Insolvency Act 1986 is deemed to be unable to pay its debts or compounds with creditors or in the event of a resolution being passed or proceedings commenced for its administration or liquidation (other than for a voluntary winding up for the purposes of reconstruction or amalgamation) or if a Receiver or Manager is appointed of all or any part of its assets or undertaking, the other party shall be entitled to cancel the contract in whole or in part by notice in writing without prejudice to any other right or remedy accrued or accruing to that party.

FORCE MAJEURE

11. In the event of the performance of any obligation accepted by Rapra being prevented, delayed, or in any way interfered with by direction of government, war, industrial dispute, strike, breakdown of machinery or plant, accident, fire or by any other cause beyond Rapra's control Rapra may at its option suspend performance or cancel its obligations under the contract without liability for any damage or consequential loss resulting therefrom, such suspension or cancellation being without prejudice to Rapra's right to recover all sums owing to it in respect of works performed and costs incurred prior to the date of suspension or cancellation.

ASSIGNMENT

12. This Contract is personal to the parties and may not be assigned or transferred without the prior written consent of the other party.

LEGAL

13. The contract shall be governed and interpreted exclusively according to the Law of England and shall be subject to the jurisdiction of the English Courts only.