The weathering resistance of quaternary HDPE composites: effects of weld lines, formulation and degradation on tensile properties. Appendix A.

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ABSTRACT: In this work, the effects of weld lines, additives and the degree of QUV weathering on the tensile behaviour of a range of HDPE composites with calcium carbonate, stabilisers and a carbon black/SEBS masterbatch are studied. The degree of weathering is characterised using FTIR-derived carbonyl, double-bond and carbonate indexes based on curve fitting, to allow for the fairer comparison of specimens with and without calcium carbonate. Weld-line specimens exhibited more rapid degradation than that seen in the reference specimens, while the exposed surfaces of the specimens degraded more quickly than the unexposed surfaces. ISO G154 Cycle 1 and Cycle 6 weathering protocols were compared. The additives were found to be effective at decreasing oxidative degradation, albeit with reduced effects at higher loadings and in mixed systems. These findings were mirrored in the mechanical properties of the specimens, with the modified specimens even exhibiting broadly improved properties with increasing ageing. Elongation at break was most sensitive to weathering, with increasing degradation with increasing weathering across almost all specimens.

Keywords: high-density polyethylene, calcium carbonate, carbon black, hindered-amine light stabiliser, weathering stability, tensile testing, QUV, weld lines

FTIR

Table A1: ATR-FTIR peaks identified between 1500 cm^{-1} and 1800 cm^{-1}, with their assignment (in the carbonyl region) based on literature values.

Position (cm^{-1})	Species
1518	
1529	
1537	
1546	
1556	
1564	
1573	
1581	
1598	
1606	
1614	
1622	
1633	
1644	
1650	
1661	
1669	
1675	
1682	Ketones, acids alpha, beta unsaturated[1,2]
1690	
1697	γ-Ketoacids, keto group[1,2]
1705	γ-Ketoacids, acid group[1,2]
1715	Carboxylic acids (associated)[1,2]

1723	Ketones[1,2]
1732	Aldehydes[1,2]
1740	Esters[1,2]
1748	Peracids[1,2]
1757	Free carboxylic acids[2]
1769	Carboxylic acids (isolated)[1,2]
1778	Peresters[1,2]
1794	Carbonate ion (calcite)[3]
1800	Carbonate ion (calcite)[3]
1809	

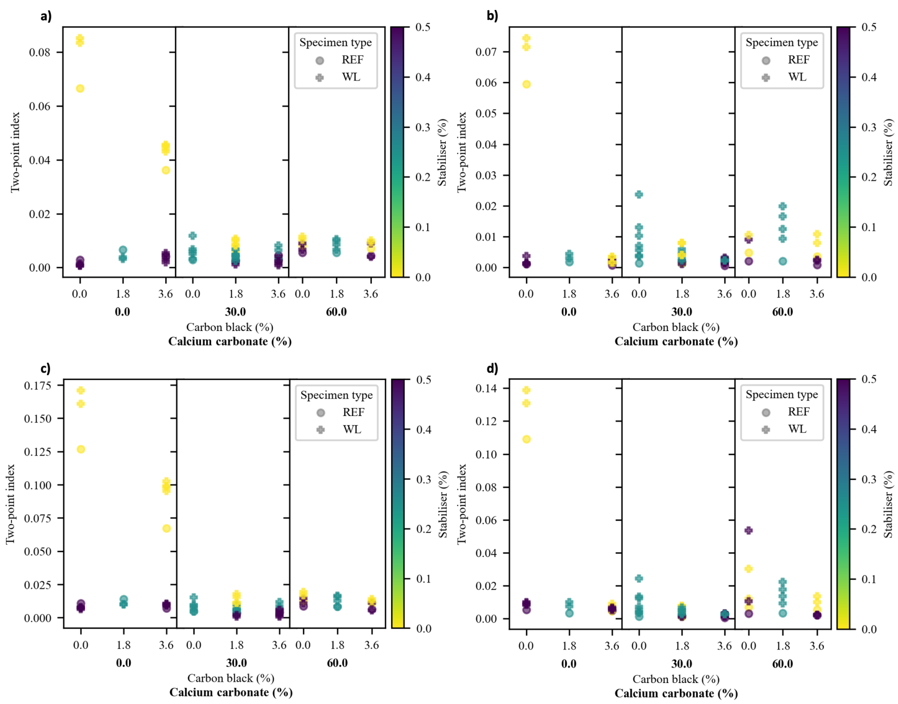

Figure A1: (a) Front and (b) back unadjusted carbonyl indexes calculated as per Almond et al[4] as a function of formulation and specimen type for the materials exposed to the maximum weathering level. (a) Front and (b) back carbonyl indexes calculated as per modified Almond et al[4] as a function of formulation and specimen type for the materials exposed to the maximum weathering level.

Tensile properties

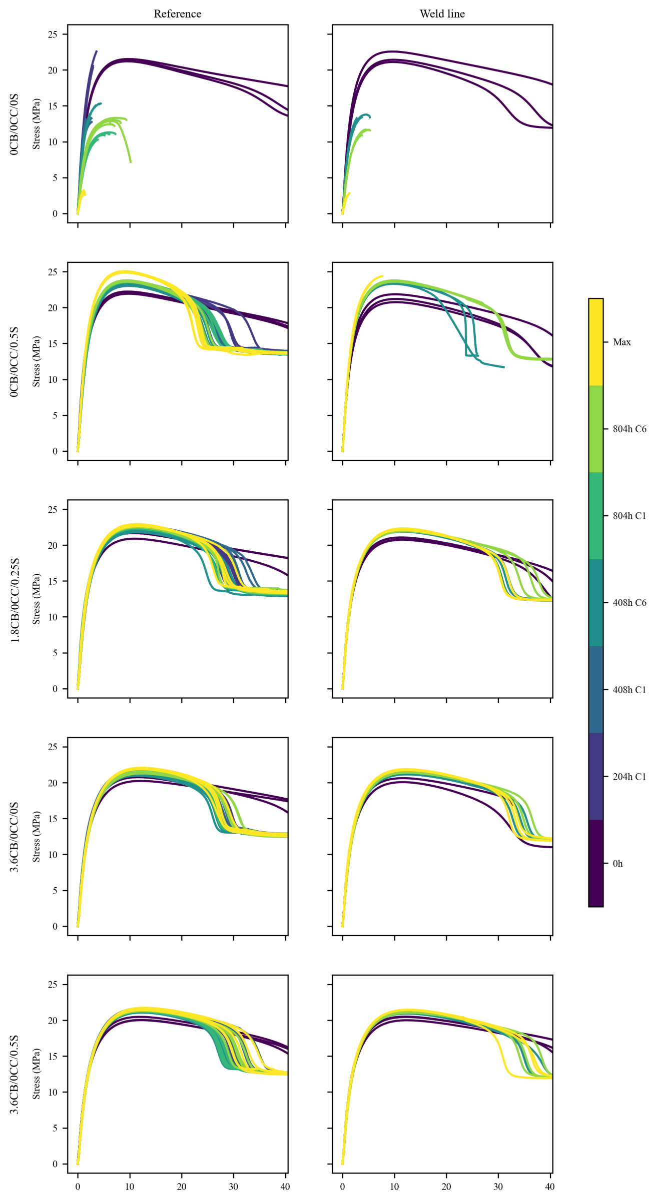

Figure A2: Stress-strain curves for specimens of the 0CC formulations, presented as a function of specimen weathering.

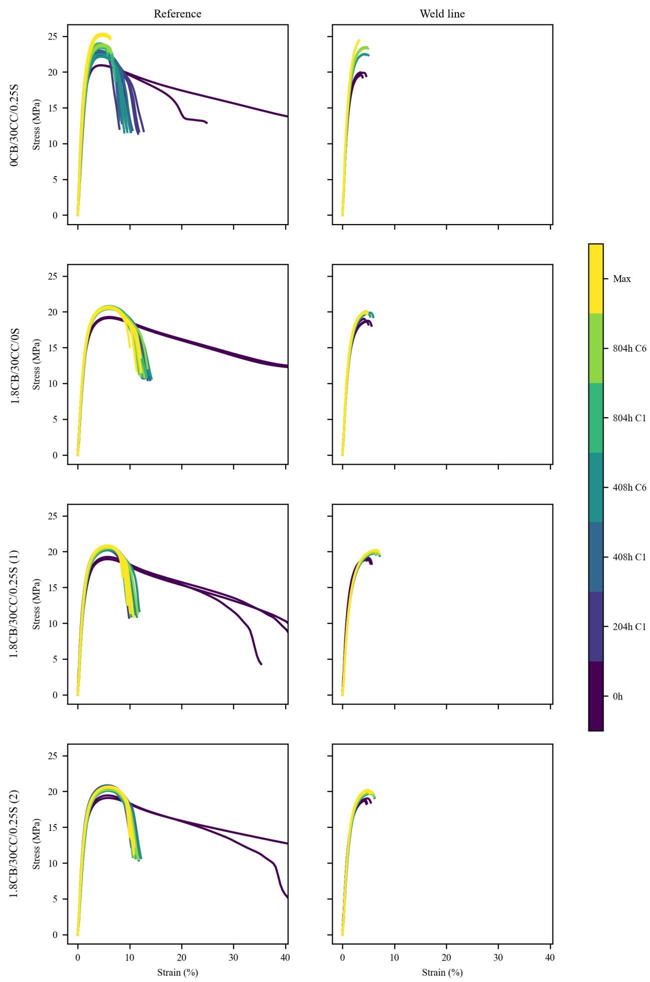

Figure A3: Stress-strain curves for specimens of the 30CC formulations (part 1), presented as a function of specimen weathering.

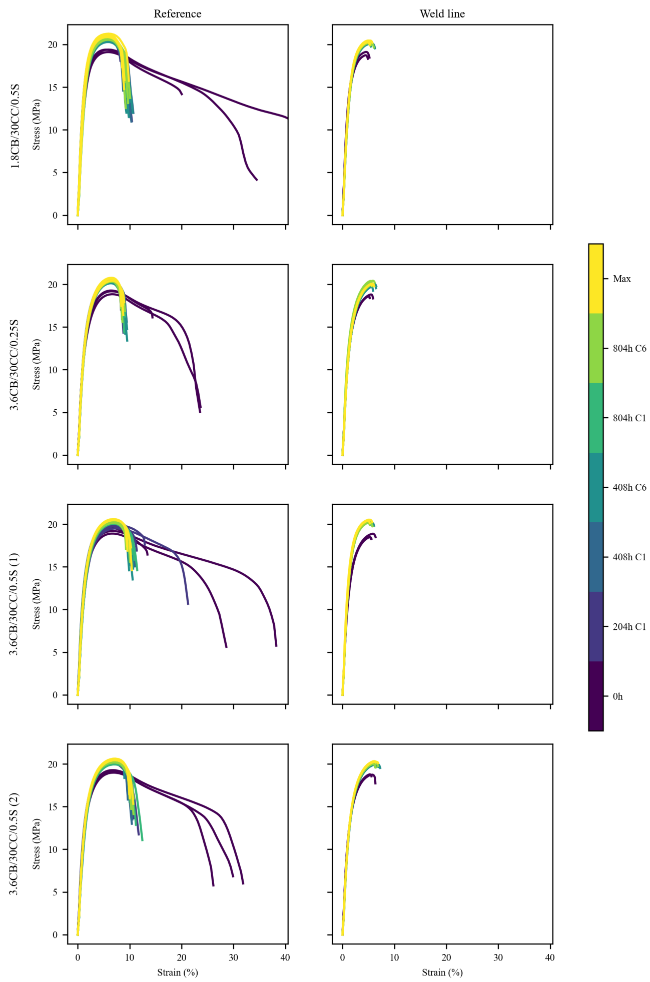

Figure A4: Stress-strain curves for specimens of the 30CC formulations (part 2), presented as a function of specimen weathering.

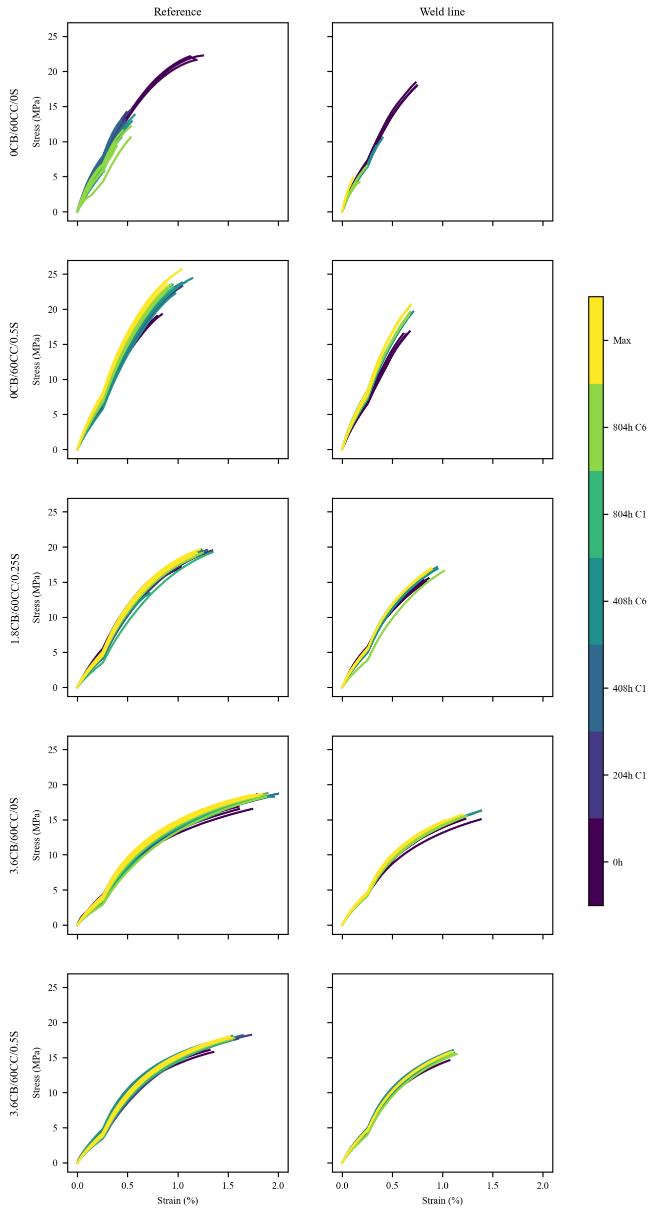

Figure A5: Stress-strain curves for specimens of the 60CC formulations, presented as a function of specimen weathering.

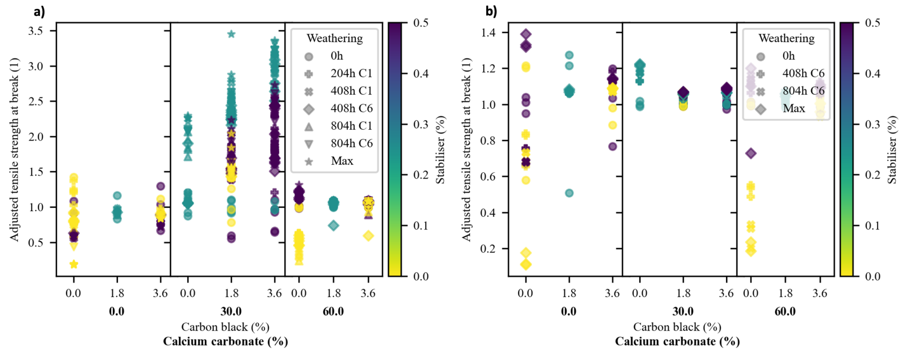

Figure A6: Comparison of adjusted strength at break as a function of ageing time and formulation for (a) REF and (b) WL specimens.

References

1. M. Salvalaggio, R. Bagatin, M. Fornaroli, S. Fanutti, S. Palmery, and E. Battistel, Polymer degradation and stability **91**, 2775 (2006).

2. W. Yagoubi, A. Abdelhafidi, M. Sebaa, and S. Chabira, Polymer Testing **44**, 37 (2015).

3. F. A. Andersen, L. Brecevic, et al., Acta Chem. Scand **45**, 1018 (1991).

4. J. Almond, P. Sugumaar, M. N. Wenzel, G. Hill, and C. Wallis, e-Polymers **20**, 369 (2020).