Fatigue behaviour of PVC nanocomposites

Noorasikin Samat[1], Indra Kemal[1] , Robert Burford[2], Alan Whittle[3] and Mark Hoffman[1]

The School of Materials Science and Engineering[1], The School of Chemical Science and Engineering[2],
The University of New South Wales , Sydney, NSW 2052, Australia

Iplex Pipelines Australia Ltd[3], Chipping Norton, NSW

Introduction

PVC materials have been used extensively in many applications such as pipes and windows. However, pure PVC has inherently low impact resistance and poor thermal stability. The enhancement in mechanical properties of PVC is obtained via modification involving the addition of rubbery or inorganic particles. Inorganic particles are preferred due to their effectiveness in reducing the material costs. Among the several available inorganic fillers, calcium carbonate ($CaCO_3$) is found to significantly improve the impact strength of PVC. Several previous studies have reported that $CaCO_3$ particles in the nano-size range resulted in superior impact strength compared to micron-sized $CaCO_3$ particles. The fatigue behaviour in PVC/nano-$CaCO_3$ (PVC/NPCC) composite systems has not yet been investigated. Moreover, for water supply applications, fatigue crack propagation needs to be critically analysed.

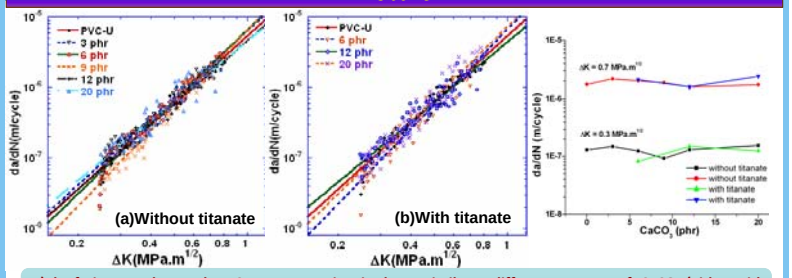
Therefore, the objective in this study is to determine the fatigue propagation behaviour on PVC-U reinforced with nano-$CaCO_3$ in concentrations of 3 to 20 phr. The effect of titanate coupling agent for this system is also investigated.

Experimental Work

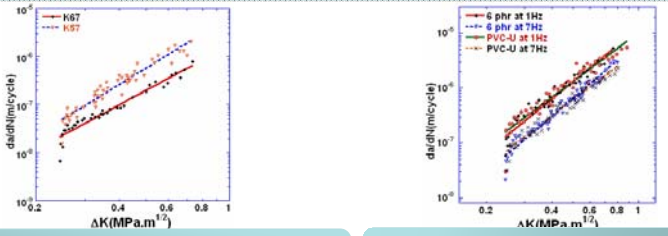
The compounding of PVC with inorganic fillers was conducted using a two roll-mill in which nano-particles were added in quantities ranging from 3 phr to 20 phr. Specimens were then compression-moulded into approximately 4 mm thick plates at 175°C prior to being cut into compact tension (CT) specimens.

Fatigue testing was performed with a sinusoidal waveform on MTS 810 Servo-hydraulic Testing Machine at a frequency of 7 Hz and the crack length was measured using a travelling microscope.

Result

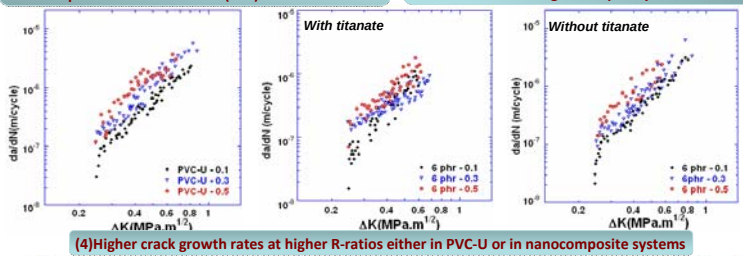


(1)The fatigue crack growth PVC nanocomposites is almost similar at different contents of $CaCO_3$ (either with and without titanate) ; feature of rate with different slopes at low and high stress amplitude

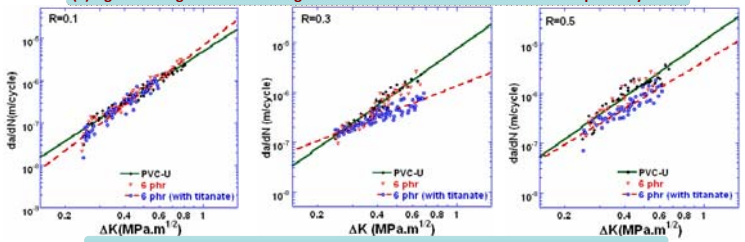


(2)Nanocomposites that were fabricated with Mw of K67 showed higher in fatigue resistance than nanocomposites with lower Mw (K57)

(3)The sensitivity of PVC remains similar even with the addition of nano-$CaCO_3$; lower crack growth rate is observed at higher frequency

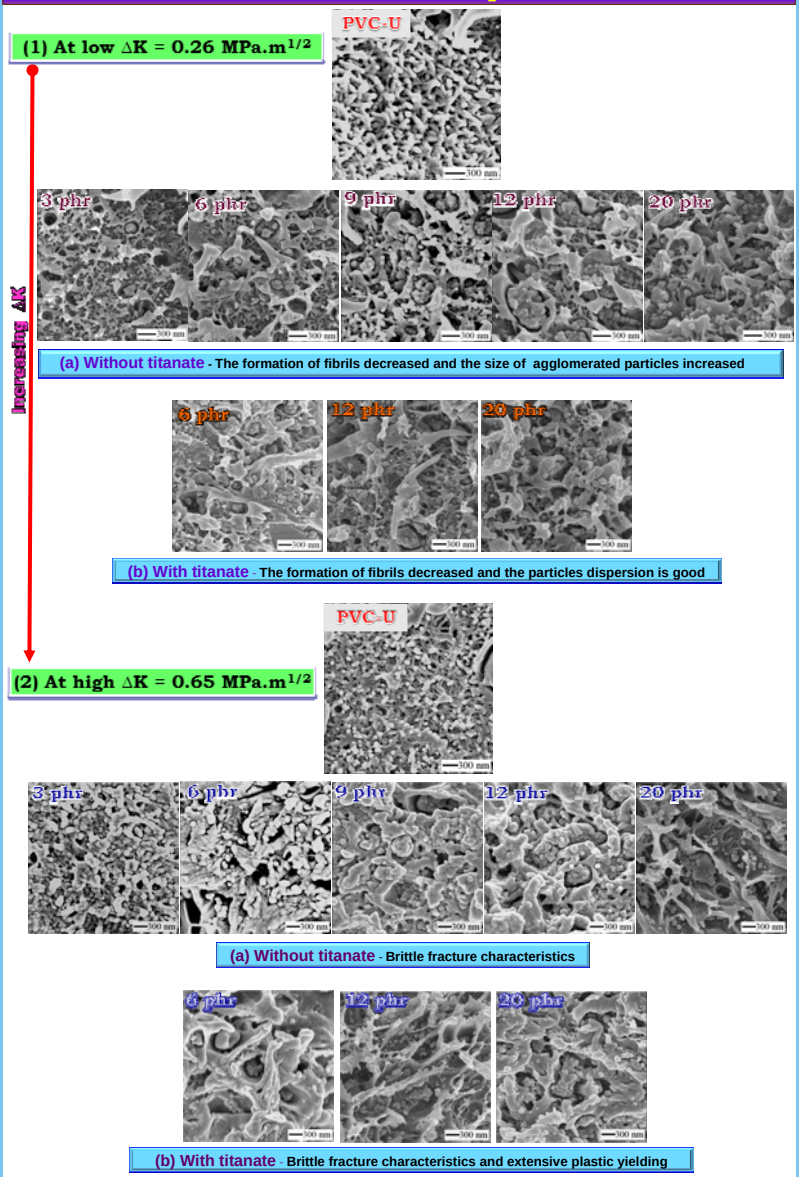


(4)Higher crack growth rates at higher R-ratios either in PVC-U or in nanocomposite systems

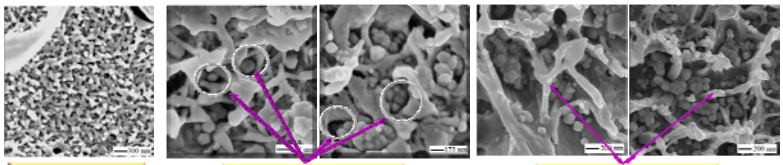


(5)Higher fatigue resistance in nanocomposite-treated with titanate at higher R-ratios

Fracture surface inspection



Energy Absorbing Mechanism



Conclusion

1)The addition of rigid nanometer-sized did not significantly affect the fatigue resistance of PVC-U.

2)The coupling agent improves the particle dispersion and this condition contributed slightly to enhance the fatigue resistance.

3)Debonding and ligament yielding are the main mechanisms for fatigue fracture in this system for low and high content of particles respectively.