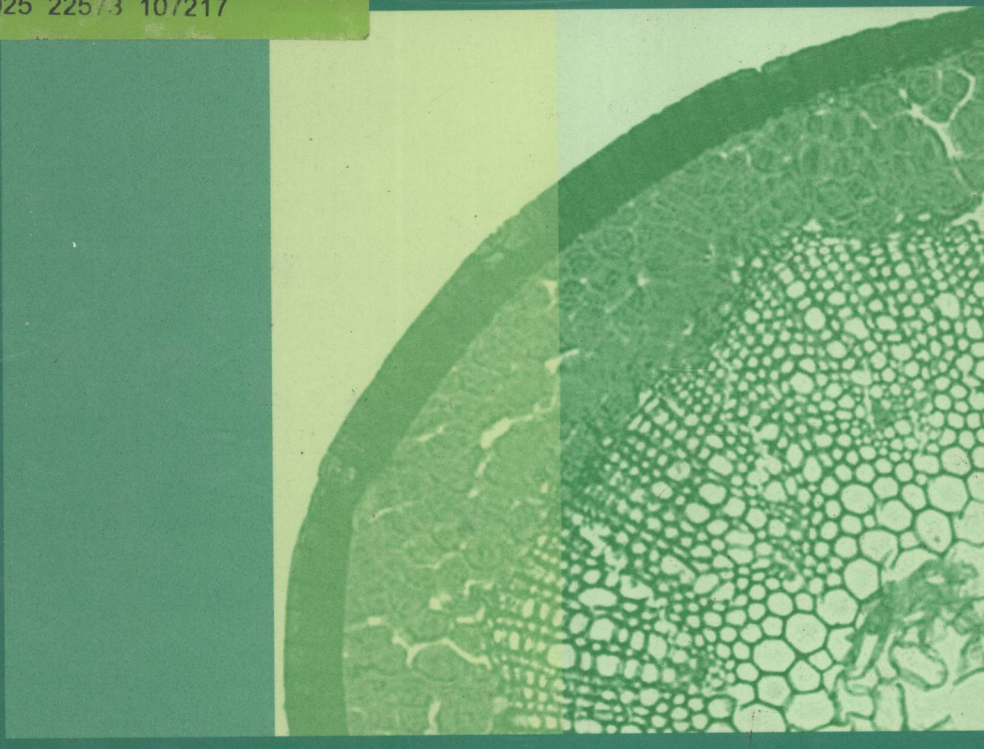

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Polymer composites and the environment

Edited by Caroline Baillie

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1

Why green composites?

C. BAILLIE
Queen's University, Canada

1.1 Introduction

Often when pursuing research into green composites we say that we are protecting the environment, that we are working for nature. We may as well stop kidding ourselves – nature will be fine; nature will work out OK and adapt to the changes. It's humans that will cease to exist if we continue the way we are at present. Some scientists and engineers have realised that they need to take responsibility for the outcome of their work. Researching ways of creating faster machines and bigger toys, without due consideration of the effects on the environment or on people, is irresponsible. This book represents some of the workers who have, over the last 10 years or so, decided to change the direction of their research to address some of these issues. We have recently been seeing an increase in the number of researchers working in this area and it is time to reflect on the progress and purpose of our work to make sure that we are in fact doing what we say we would like to do.

1.2 An environmental footprint and life cycle assessment

In this context we are defining green composites as composites that are designed with the lowest environmental 'footprint' possible. Furthermore, we are focusing on fibre-reinforced polymer composites in this book as these are the most abundant material group of the composite family in use. In this chapter we will explore some of the assumptions we make and consider the life cycle of such materials, not only from 'cradle to grave' but beyond the grave into the after life.

What do we mean by an environmental footprint? What factors must be considered? We consistently hear the terms 'green', 'eco', 'sustainable', 'environmentally conscious', 'life cycle', 'clean' and assume we know what is meant by them. We also often label our work with these terms in order to

generate funding from governmental bodies who in turn use the terms to satisfy their promises. But is anyone actually making any difference to the damage we are doing to our planet? We need to consider the impact that our material choice and design will have on the society and the environment (Rose and Baillie – *Navigating the Materials World*, Academic Press, 2003). Life cycle assessment is defined as 'an objective process to evaluate the environmental burdens associated with a product, process or activity by identifying energy and materials used and wastes released to the environment, and to evaluate and implement opportunities to effect environmental improvements' (Society of Environmental Toxicology and Chemistry, SETAC, Code of Practice, 1991). I dispute the objective part of this definition. Life cycle assessments are so difficult, often so subjective in their evaluations and so complex, that they are frequently ignored, or taken as an add on at the end of a project. Many companies insist on carrying out an LCA or life cycle analysis before their design can be realised. An environmental LCA helps us to quantify how much energy and material are used and how much waste is generated at each stage of a product's life.

The analysis takes place first but, after this, the life cycle assessment needs to take place, which is where the interpretation and value judgements come in, e.g.

- Is it worse to use up more energy in transport or to produce more factories?
- Is it worse to burn and create harmful gases or to create landfill?
- Is it worse to dump or to use up energy in recycling?
- Is it worse to have the risk of food poisoning or waste food or increased packaging?

Assessment of the impact on the environment is therefore considered at each stage: resources, production, distribution, use, disposal or re-use.

Many such LCAs have actually proved the project to have been a waste of energy in itself. In a recent report from a CRAFT project to produce natural fibre composites in which I was involved (CRAFT project European Commission report (BES2-3163), 2000) we compared natural mat- (NMT) and glass mat-reinforced thermoplastics (GMT). A comparison was made between GMT and NMT manufactured by a current production method of prepreg followed by compression moulding into an automotive and non-automotive part. The LCA analysis was performed for both the non-automotive and automotive part and for three different types of performance requirements, i.e. stiffness, strength and impact resistance. The results of LCA showed that, for most cases, the environmental impact of NMT material is higher than the reference GMT. Despite their 'green' image, natural fibre composites are not necessarily an environmentally friendly alternative to glass fibre

composites in applications where strength and impact are the performance drivers. The reasons for this include the need for pesticides and other chemicals to grow the flax fibre and the higher fibre loadings needed to fulfil the impact and strength criteria. Even in the case of stiffness-based non-automotive applications, where no higher fibre loadings are needed to meet the performance requirements, the differences in environmental impact between GMT and NMT are very small and in the current analysis the poorest performance was shown for NMT due to the negative effect of pesticides. In the case of automotive and stiffness critical applications NMT composites do seem to perform better than GMT composites. This reduction in environmental impact for NMT composites is, however, mainly due to the lower weight of natural fibre composite parts, which leads to lower fuel consumption during the use of composites and not so much the result of the use of 'green' natural fibres. Hence, the advantages of natural fibre composites are relevant if weight savings are obtained over glass fibre composites.

1.3 Drivers for change

From the above it would seem as if only those researchers who are altruistic would be involved in this game. In fact, there are many drivers for the change we currently observe. Global concerns are considered by the Kyoto Protocol, national concerns by government legislation, and local companies in turn make a response to the legislation. All of this will influence funding mechanisms and availability of funds for researchers.

Global responses to climate change are critical at the time of writing where countries are deciding upon the Kyoto Protocol. Reports of a lecture by Michael Grubb of Imperial college to the Royal Institute of international Affairs (*The Independent*, 5 November, 2003) quote him as saying:

> the US is starting to pour billions of dollars into research on technologies like carbon sequestration and hydrogen. Unfortunately, pursuing climate technology while eschewing emission caps is like designing a fancy car while opposing all efforts to put an engine in it... . Governments are not good at delivering industrial technologies: there has to be a market for them.

The argument may be said to be true of green composites in automotive and other applications. In Canada at present there is a push to make a new profitable market from the use of agricultural fibres in composites. Economic arguments alone will not cause this technology to take off. Rumour has it that local industry may not become interested in changing to more eco-friendly products because, even if the Canadian Government encouraged them to do so with legislation, they would simply sell 'over the border'. One of the largest markets for natural fibre composites is the US automotive

sector who currently do not appear to have the same drivers as the European market. The EU Directive for automotive parts has meant that many companies in Europe have started to consider environmentally friendly alternatives to fuel and materials for production. The Directive stipulates that re-use and recycling of end-of-life vehicles must increase to 95% by 2015. Further details are given by Tucker in Chapter 10. He tells us that disassembly is a concern and costs associated with dismantling plastic components from cars are too high at present. Tucker would suggest 'design for disassembly'. The European Community approach to waste management is based on two complementary strategies: avoiding waste by improving product design and increasing the recycling and re-use of waste.

The EU Landfill Directive (1999) states that, by 2010, the amount of biodegradable municipal waste going to landfill must be reduced by 75% of the total produced in 1995. The EU Packaging Waste Directive (1997) states that there must be 50–60% recovery and 25–45% recycling by 2006. For a city like London, this means that there must be alternative routes for waste of between 2 and 4 million tonnes per year. The UK has responded by developing its Government Waste Strategy (2000). This states that 30% of all waste produced must be recycled or composted by the year 2010. Furthermore, the UK has responded to the EU Directives by bringing in a landfill tax system that forces companies to think about end of use. Hence, response to EU Directives creates a huge driver and support for research in the green materials area. In the US the Environmental Protection Agency Office of Solid Waste 'supports' reaching a goal of 35% recycling by 2005 (American Plastics Council, 2001, National Post Consumer Plastics Report). Implementation of legislation is, of course, another huge factor.

Hence it might be that Liverpool in the UK cannot ask its citizens to take responsibility for the environment as they do not have a collection system in place and the locals would use more energy in fuel driving to the nearest collection point in Chester. Kingston, Ontario in Canada, on the other hand, represents one town that has a well-established curb side collection system in place. However, it is rumoured that much of the plastic waste gets sent to other countries as an export. Those countries obviously do not have enough of their own waste.

1.3.1 Swings and roundabouts

We cannot pour money into environmental research until legislation reinforces the changes that ensue. We cannot encourage participation of profit driven corporations unless legislation supports such changes. Furthermore, we cannot create environmental schemes that rely on the participation of communities of people who produce waste when the infrastructure is not there to support the schemes. The drivers for, and the national and global economic,