Sustainable Technology Solutions – A case study by NZ Product Accelerator model of engagement of supply chain partners

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ABSTRACT

Environmentally friendly, sustainable Natural Rubber (NR) based pylons that fulfil all the requirements of flexible pylons for harness horse racing tracks have been developed and commercialized. NR's inherent properties such as good resilience, impact resistance, flexibility and excellent overall performance has made it the ideal choice for this application. Use of non-leaching bio-based polymeric antioxidants have further increased the performance of rubber pylons. Cure characteristics, retention of mechanical properties after ageing at elevated temperatures and their non-staining properties are discussed.

The development of rubber pylons has replaced the highly plasticized PVC pylons that become brittle in service losing its integrity due to plasticizer migration.

The Product Accelerator (PA) model of engagement through local and international technology partners, industry partners and service providers has made it possible to take rubber pylons rapidly in to the global markets.

Keywords: rubber pylons, bio-based antioxidants, supply-chain engagement, sustainability, rapid commercialization,

1 INTRODUCTION

Rigid PVC is flexibilized by the addition of plasticizers that are by design not covalently bound to the polymer matrix, makes them highly susceptible to leaching. The potential risks related to some phthalates such as DEHP include degradation of the polymer during service causing surface embrittlement and micro-cracking, yielding micro-particles that persist in the environment. Use of phthalates, which are incorporated into plastics as plasticizers comprise ~70% of the U.S. plasticizer market, is becoming under increasing pressure in Europe in several applications. In February 2007, the Technical and Scientific Advisory Committee of the US Green Building Council released its report [1] concluding that the risk of dioxin emissions from PVC puts it consistently among the worst materials interns of human health impacts [2].

On the other hand, the combination of unique morphology, excellent physical and mechanical properties, cost effectiveness and sustainability make Natural Rubber (NR) an appealing constituent for many industrial applications including tyres, rubber springs and vibration mounts. NR has high structural regularity, providing it with unique characteristics such as high tensile and tear strength, good resilience, high elasticity, excellent impact resistance, good low temperature performance and excellent overall performance and durability in service conditions.

The case study discussed here show the development of a speciality product based on environmentally friendly sustainable NR with the supply chain engagement to meet the requirements of pylons exposed to harsh environment conditions in some parts of NZ and Australia.

2 THE COLLABORATION MODEL

The Product Accelerator (PA) model of engagement through technology partners, industry partners and service providers to commercialize new products into local and international markets has prompted undertake this project to improve performance of pylons in service. The NR based pylons have been developed at an international technology partner institution, with the technical inputs from PA network expertise.

The PA is a Ministry of Business, Innovation and Employment (MBIE) funded research programme established to accelerate basic materials and manufacturing research into high value commercial products using various models including pathways to markets with robust project delivery processes. This case study is based on a strategy to get lead companies in NZ involved in the PA model of supply chain engagement to facilitate rapid commercialization.

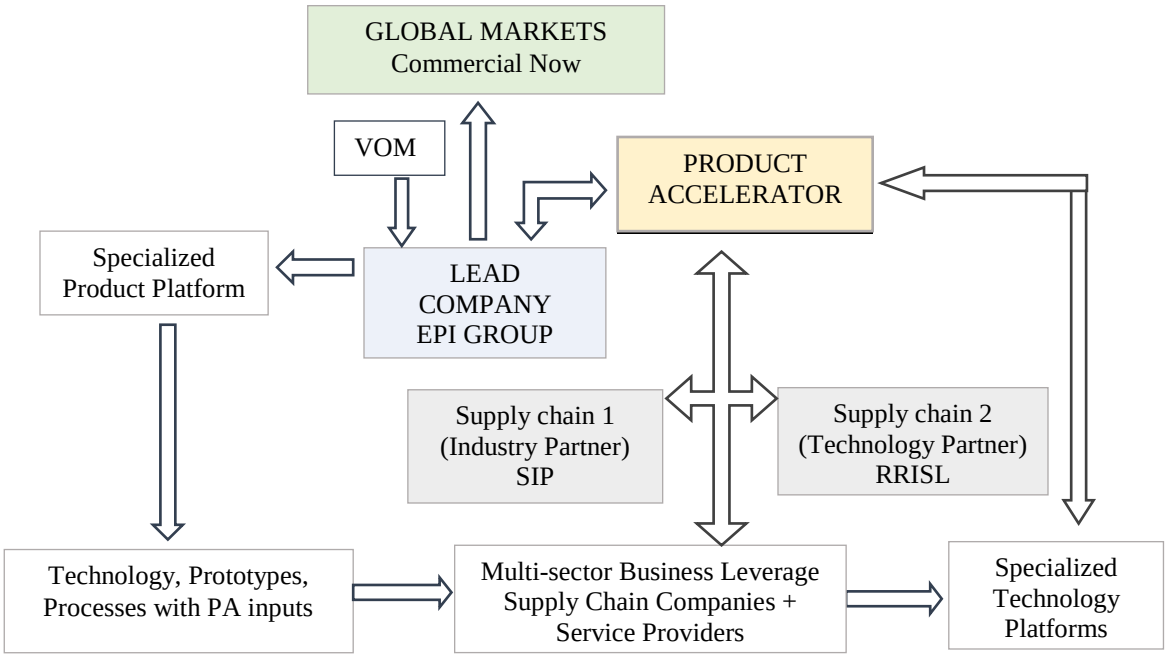


Figure 1: Case Study – PA Model of Engagement of Supply Chain

Figure 1 shows the PA model adopted to get international technology partners and service providers to commercialize the development of rubber pylon into local and international markets. This approach constitutes another aspect of PA multidisciplinary research contributions [3-6] engaging the expertise in its network partners in various fields. Testing of rubber pylons has been done at international technology or service provider, Rubber Research Institute of Sri Lanka, RRISL listed in PA portfolio. The manufacturing of prototypes and commercial scale production were done and Samson International Plc SIP. The commercialization of pylon is handled by EPI Group in NZ.

Interestingly, this type of counterproductive interaction is very productive and such connections between the researcher even with international supply chain partners, technology partners and the industry person may well exist and be sustained over a period of time across many other technology platforms. Very often these connections demonstrate alignment in more fundamental values – such as contributions to community, to support the developing countries to open up new markets in develop countries and expand PA network connections globally.

3 EXPERIMENTAL

An evaluation of the performance of rubber pylons is discussed here. The formulations in Table 1 were used to study leaching from pylons at high temperatures. Cure characteristics, mechanical and tensile properties and also the retention of properties after ageing at elevated temperatures were recorded and compared with the control (Table2). As an extension to this work, the possibility of researching bio-based polymeric antioxidants developed at Scion, NZ, in rubber compounding was trialled. This has opened up the opportunities for low cost sustainable bio-based polymeric antioxidants in rubber compounding as possible replacement of generally toxic, low molecular weight organic antioxidants that could probably leach out especially from products meant for outdoor applications. The bio-based polymeric antioxidants could also increase the life cycle of rubber pylons adding cost benefits in maintenance of racing tracks.

4 RESULTS AND DISCUSSION

The accelerated unique working model administered by the PA to develop and grow high-technology multi-materials-based export markets, by collaboration with the supply chain partners with the materials manufacturing industry has been successful. When deciding the supply chain partners with the requirements of multidisciplinary nature of technologies by the lead companies in NZ, the PA takes into account the facilities already available, first with the local partners failing which the international partners, for fast access of facilities to produce prototypes and potential commercial scale manufacturing.

In this project, the focus was to work with a manufacturing company and a service provider to develop a cooperative research programs to deliver a specialized export product. Introducing rubber to replace PVC with the

expertise and testing facilities at the RRISL and in-house R/D facilities at SIP with the input from in-house technical expertise at the PA made this project commercially viable.

The PA has in-house technical expertise in high-technology composites, ceramics, conducting polymers, biomaterials, and coatings and most importantly in selecting the right materials for new products has helped to identify the market-led projects that need quick pathways to commercialization. PA has the potential to turbo-charge the development of manufacturing technology platforms and identify quick action needed to facilitate the commercialization process.

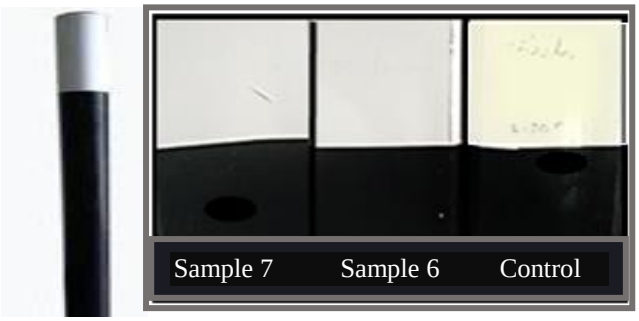
The IRHD hardness required for the pylon to perform well has been specified to be in the range of 80. After accelerated ageing all mechanical properties tested have shown no deterioration of the base material.

The control used in this study include the commercial antioxidants/ anti-degradants, based on amines. These compounds have some drawbacks such as surface blooming and volatilization, with a consequent loss of effectiveness in service. Other problems with these compounds include, leaching and migration in service and the deterioration of mechanical properties by causing disruption of the stress propagation through the polymer chains.

The results in Table 2 and Figure 1 show the leaching of staining anti-degradant is caused mainly by the presence of amine anti-degradant, Pilflex 13/Vulkanox 4020 i.e. N-1,3-dimethyl butyl-N'-phenyl para-phenylenediamine which has definite propensity to discolour the goods if they are exposed to light.

The phenolic antioxidant, Pilnox TDQ, 2,2,4-Trimethyl-1,2-dihydroquinoline – TMQ is not causing any leaching of anti-degradants from rubber pylon. Both these anti-degradants were used in the control. Introducing a bio-based polymeric antioxidant in conjunction with TMQ showed properties acceptable to the application and add a sustainability component and a possible cost reduction to the end product.

The results of an accelerated leaching test conducted show that the staining problem onto the white sticker glued to the pylon can be overcome by using a polymeric, high molecular weight bio-based antioxidant which is UV and heat stable. (Figure 2)



(2a) (2b)

Figure 2a: A rubber pylon with a white sticker used for better visibility
Figure 2b: Accelerated staining test on anti-degradant leaching from rubber to white sticker

Ingredients	**Formulations (phr)**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**Control 8**
Base formulation*	282	282	281	282	282	**280**	**280**	**280**
Pilflex 13 /Vulkanox 4020**	1	1	-	-	-	-	-	**2**
Pilnox TDQ /Vulkanox HS***	-	-	-	-	-	**3**	**1**	**2**
Biobased AO-A	1	-	2	-	3	**1**	**3**	-
Biobased AO-B	-	1	1	2	-	-	-	-

Table 1: Formulations used for rubber pylons

*Base formulation contains **NR, EPDM rubber blend (4:1)** and carbon black (35%) to give excellent UV and ozone resistance to rubber backbone and other standard vulcanizing ingredients to give good mechanical properties

****Pilflex 13/ Vulkanox 4020** - Discolouring and staining amine anti-degradant (MP 45^{0}C)

*** Pilnox TDQ – A staining phenolic anti-ozanant to protect the vulcanizes against damaging external influences

Bio-based AO- A and B are natural polymeric antioxidants derived from plant sources in NZ

Physical properties - Before aging	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Control 8**
Hardness(IRHD)	78	81	79	79	78	**81**	**78**	**78**
Specific Gravity	1.20	1.24	1.23	1.25	1.23	**1.25**	**1.20**	**1.22**
Tensile **strength** (Mpa)	10.25	10.12	10.15	9.86	10.21	**10.23**	**11.00**	**9.88**
Physical properties after aging at 100^{0}C for 48hrs								
Increase in Hardness after aging	3	2	2	3	2	**4**	**3**	**2**
% Tensile Retention	95	95	95	95	95	**95**	**95**	**94**
Staining test (aged at 100^{0}C for **48hrs followed by** hot air blown on to the white stickers	M	M	N	N	N	**N**	**N**	**M**
Stain on white stickers with hot air blown on to the sticker shown in Figure 2								

Table 2: Some mechanical properties of rubber pylons before and after accelerated ageing test and Staining tests with commercial anti-degradants and bio-based polymeric antioxidants

5 CONCLUSIONS

Incorrect material selection is one of the most common causes of failures experienced in product manufacture and successful material selection requires a judicious scientific approach in order to evaluate the requirements of the application.

Working closely with the commercial scale manufacturer, enabled the product development team to replace highly plasticized PVC with natural rubber based formulation and look at the effects of bio-based polymeric antioxidants derived in New Zealand in rubber compounding. Surprisingly, the introduction of the low cost polymeric bio-based antioxidants in the pylon formulation was effective and it was helpful to overcome an issue related to antioxidant leaching from rubber on to the white collar that is glued on top of the pylon for the purpose of better visibility in the horse racing tracks.

The case study discussed in this paper clearly shows that the model adapted by the ^{NZ} Product Accelerator to accelerate commercial opportunities for NZ companies have been successfully achieved. This unique working model administered by the PA has enabled the local lead company to working closely with technology providers and service providers in developing new customized products needed by demanding customers. This model also allowed the lead company to access a manufacturing technology that was not readily available in the manufacturing industry in NZ and offer the global end users a high quality better performing product meeting all the requirements.

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