



Only time will tell

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The past 40 years has seen the world's population almost double from 3.8 to 7.1 billion and footwear consumption almost quadruple from 5.8 to 21.9 billion pairs. The same period has also seen a dramatic shift in footwear manufacture from West to East mainly in a quest to reduce costs. It has also seen the development of a range of soling materials made from petroleum-based polymers which have helped to make this phenomenal growth in footwear manufacture possible. These include PVC (polyvinyl chloride) in the 1960s, PU (polyurethane), TPR (thermoplastic rubber) and TPU (thermoplastic polyurethane) in the 1970s, followed by EVA (ethylene vinyl acetate) in the 1980s.

It has also seen an awareness of how the demands placed by this population growth on the world's resources and its effects on the environment has grown from a few warning voices into a major consumer concern. The last 10-15 years has seen environmental soundness become a strong influence on the footwear industry, where its products have joined the general trend of needing to appear green and non-polluting. To this end most major

brands have taken a very strong position on certain materials with Nike publicly announcing that it is eliminating all PVC from its footwear. Although in its case it mainly concerns PVC coated upper materials, other companies have made similar announcements involving PVC as a soling material.

In spite of all this, PVC is global leader in materials used for footwear soling at 2,839 Ktonnes out of a grand total of all materials of 10,558 Ktonnes in 2012. The reasons are quite simple. PVC combines good wearing properties at a lower cost than the alternatives and is also easy to process using basic injection moulding technology. When we look at the data for PVC usage over the last 20 years (*Figures 1 & 2*), it is quite clear that it in fact enjoyed significant growth up to 2007. The stabilising effect of environmental pressure only appears to have kicked in over the last six years.

The downside is that it is extremely unfriendly in environmental terms in that it cannot be bio-degraded and, if incinerated, gives off highly toxic fumes and leaves a carcinogenic residue. Unfortunately, as things stand at present, there appears to be no way of

replacing the fossil fuel content with more sustainable substitutes to make a 'greener' compound. It would of course be possible to replace it by PU, TPU or TPR except that all three are in varying degrees more expensive and difficult to process. The on-going demand for low cost footwear in many parts of the world therefore makes it extremely likely that PVC will remain with us for some time to come.

HOW VIABLE ARE SUSTAINABLE ALTERNATIVES?

The move towards producing shoe soles with a stronger environmental image has been more successful with regard to PU and TPU. Whilst there have been attempts to introduce bio-based polyols into the mainstream of PU products it hasn't really taken off with footwear until the last few years when there has been a sudden flurry of activity. There are two key approaches, both focusing on the polyester polyol which makes up around 60% of a PU or TPU formulation. Several approaches have been developed for obtaining polyester polyols based on non-oil routes.

For instance, Huntsman PU in conjunction with Novomer Inc. has pursued the idea of producing a new

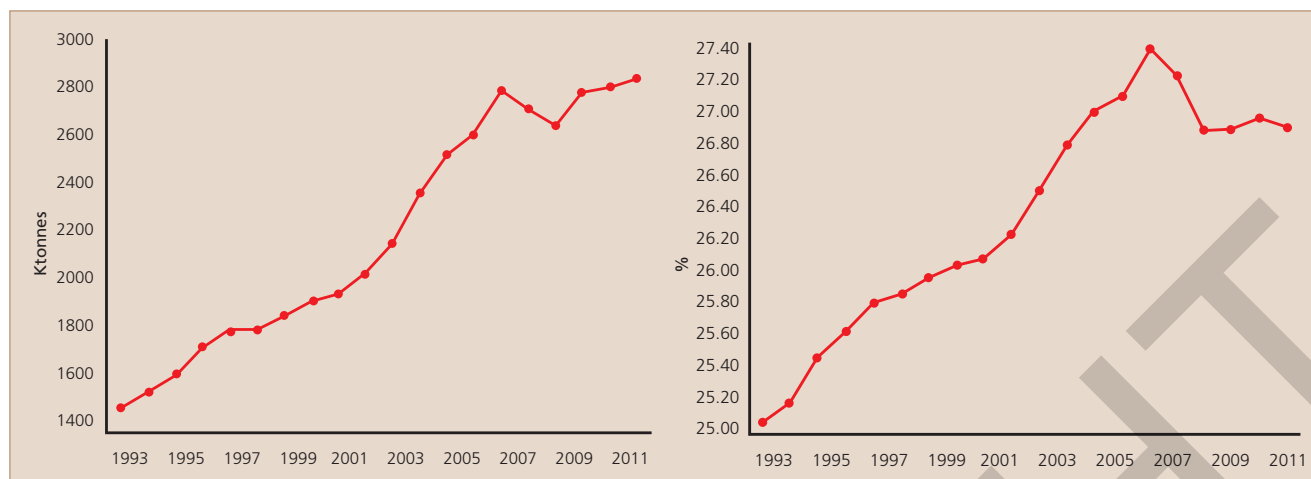


Figure 1 – Growth of PVC 1993 to 2012.

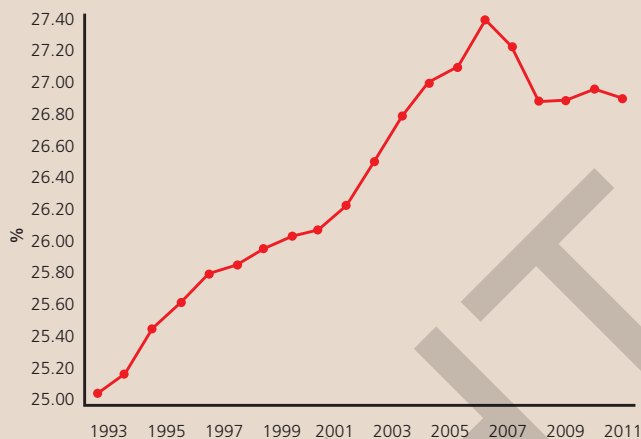


Figure 2 – PVC's percentage share of overall soling market.

class of CO₂-based polyols. These polyols increase the possibilities of developing sustainable foam alternatives for the footwear industry. Novomer has developed a unique route to high performance renewable polyols using a proprietary catalyst system which transforms waste CO₂ into polyols. This technology delivers renewable polyols that are up to 50% CO₂ by weight have a 3-9 times carbon footprint compared to existing oil-based materials and are also cost effective. Bayer MaterialScience has similarly pursued a CO₂ route to producing polyols.

Several other companies have taken a different track and developed bio-based routes to producing an alternative to Adipic acid. The one that is most advanced leads to the production of bio-based succinic acid which can then be converted into a polyester polyol using a mixture of either conventional or bio-based diols.

The leading player in this area is Reverdia, a joint venture between DSM, the life and material science company and French starch and starch derivatives manufacturer Roquette Frères, which produces the Biosuccinium brand of bio-based succinic acid (bio-SA). Reverdia has produced Biosuccinium in a 300 tonnes/year capacity demonstration plant at Roquette's site in Lestrem, France, since 2010. This facility has been used for process validation and optimisation with particular attention being paid to polymer-grade product quality. It also provides tonne-scale quantities of Biosuccinium to customers for internal testing and application development.

At the end of 2012, Reverdia started operating the world's first commercial-

scale bio-SA facility at Roquette's large bio-refinery site in Cassano Spinola, near Genoa's harbour in Italy, with a capacity of 10,000 tonnes per year. Reverdia is the only company currently employing low-pH yeast technology derived from the parent companies rather than bacteria to produce bio-SA.

Other companies are also pursuing a bio-succinic route to renewable polyester polyols include the joint venture between BioAmber and Mitsui & Co who are considering building a 17 Ktonne bio-succinic acid plant in Canada due to start production 2013/14. Piedmont Chemical recently launched renewable polyester polyols made using Susterra propanediol from DuPont Tate & Lyle Bio Products (DTL) with bio-succinic acid from Myriant Corp. 100% bio-based products. So there is clearly a great deal of intense activity on the bio-based and CO₂-based routes to the production of renewable polyester polyols that can be used in the production of PU and TPU systems for footwear soling for those manufacturers interested in establishing an environmental position.

HOW MUCH DOES IT MATTER?

How much does sustainability matter to most companies and why do they pursue it as a target? Well, a report to the recent meeting of FSK, the specialist association of foamed plastics and polyurethane, put the position rather succinctly. Dr Thomas Jostmann, Evonik Industries' head of Environment & Responsibility said "Is responsible action in chemistry just a cliché? For decades now, responsible action or 'Responsible Care' has been a *leitmotif*

of the chemical industry". Evonik now weighs the needs of society and the environment equally with those of the enterprise itself. Jostmann said the top reasons for addressing sustainability were as follows expressed in percentage terms:

- Corporate reputation 36%
- Alignment with business goals 21%
- Raising efficiency & cutting costs 19%
- Consumer expectations 19%
- New growth opportunities 17%
- Better competitive position 17%
- Leadership's personal interest 14%
- Regulatory risk 14%
- Attracting good employees 11%

Someone who is at the forefront of the quest to find sustainable alternatives, Rafael Camargo of Huntsman PU, remarks on the issue of sustainability that, "To me the success of bio-based materials, requires four factors; bio-content, performance, cost and market pull. Without these, you may have some niche applications but adoption will be limited".

On the position of sustainability, it therefore is still very early days and this will not be an easy equation to square. However, it will be very interesting to track the new opportunities offered to PU and TPU systems developers as they learn to incorporate the new renewable polyester polyols into their formulations. For instance, will polyester polyols based on bio-succinium lead to a sea-change in the production of PU footwear systems? Can they lead to lower-cost, improved processing products with the excellent properties required by the footwear industry? Only time will tell. 