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EMERGING RAW MATERIAL SUPPLY FROM CHINA

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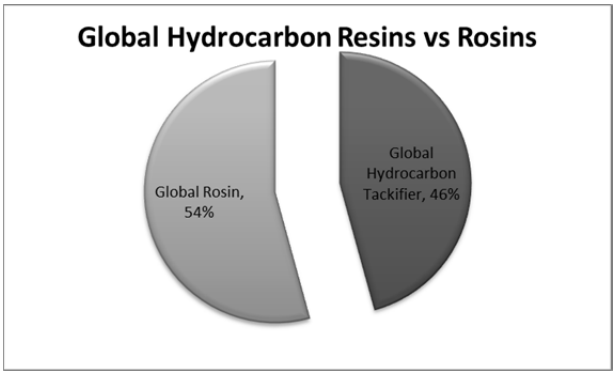
Li Zhen joined Ningbo Jinhai Deqi Chemical & Industry Co. Ltd in 2006, where he acted as deputy general manager for business development, marketing and customer technical service. He graduated from Beijing Research Institute of Chemical Industry with a M.S. in Organic Chemical Engineering, and Nankai University with B.S in chemistry. Mr. Li has had various technical, business development, commercial and management positions with multi-national companies. This includes working in senior operating positions with Sino-MNC joint venture projects supplying performance chemicals to international markets.

Chinese Hydrocarbon Resin Market

Jeffrey Li Zhen – Jinhai Deqi

This presentation puts into perspective the long history and current status of the Chinese hydrocarbon resin market and the opportunities it presents to Western World consumers. Specifically, how the industry has evolved and the rapid increase in capacity and quality improvements that has positioned that region to be a quality supplier to the pressure sensitive adhesive (PSA) industry.

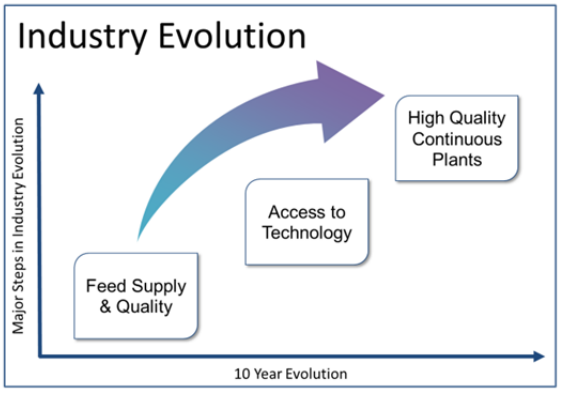


First, looking at the differences in natural versus hydrocarbon resins (HCR), one finds that today the global demand for each is about equally sized. The key difference is that natural products go into many diverse applications, while most HCRs go into adhesive applications. Further, demand and capacity for HCRs have grown, while natural product supply and demand has been relatively static.

Historically, China has been the major producer and consumer of natural resins, specifically gum rosins. Therefore, the Chinese had no need to develop HCRs, except where natural products didn't meet performance requirements. As the economy has rapidly evolved, so has China's needs and production capability.

China has followed a time-honored pattern of HCR production evolution development, starting with products where the feed is readily available, low capital investment is required and low technology barriers exist for entry. So China followed the following pattern.

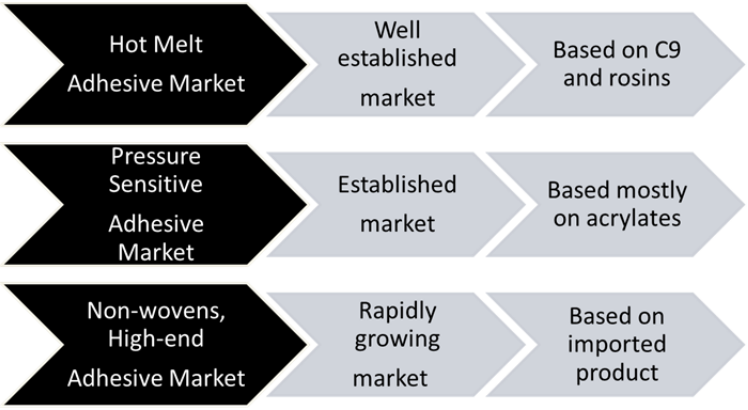
- C9, C10 or mixed feeds to purer feeds like piperylenes
- From batch processes where all process steps could be done in one vessel to continuous processes with computer control
- Easy to use technology like BF3 gas catalyst or thermal polymerization moving to powdered AlCL3 catalyst
- Non-hydrogenated to hydrogenated products
- Progressing all of these required greater access to technology



The initial production was in batch reactors that led to batch-to-batch variation in quality. Feeds and process capability led to darker-colored resins with broad

molecular weight HCRs. These products were only useful in low-end adhesive applications.

The first large continuous making of higher quality resins started around 2000, and continued until today, where there are several C5 and two hydrogenated HCR producers in China. That being said, the C5 HCR producers can't make products to be used in conventional hot-melt pressure sensitive adhesive (HMPSA) applications, and only one of the hydrogenated HCR producers makes products qualified in sophisticated hot melt adhesive (HMA) applications. So, there has been evolution in the HCR industry but there is a ways to go.

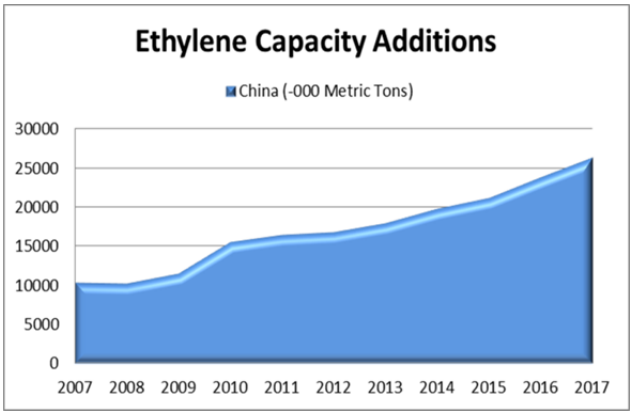


It is interesting that the domestic market demand is strong for C9 aromatic and hydrogenated HCR products in China, but HMPSA demand is mostly satisfied by acrylate-based adhesives. So, there hasn't been the drive to produce premium C5 aliphatic HCRs. Development of C5 aliphatic resins will be either driven by an export market and/or developing HMPSA production in China.

Today there are several quality C9 aromatic and hydrogenated HCRs in China, but almost no premium C5 aliphatic resins.

The rest of this presentation will now focus on the evolution of C5 aliphatic resins in China, which are important to HMPSA applications. Much like we described earlier, C5 aliphatic resins went through a similar evolution initially making broad molecular weight, dark color resins with variable quality.

With the advent of improved feed supply, there were several large continuous C5 HCR units built over the last decade. Products from these units had improved quality sufficient for rubber modification and road-marking applications.

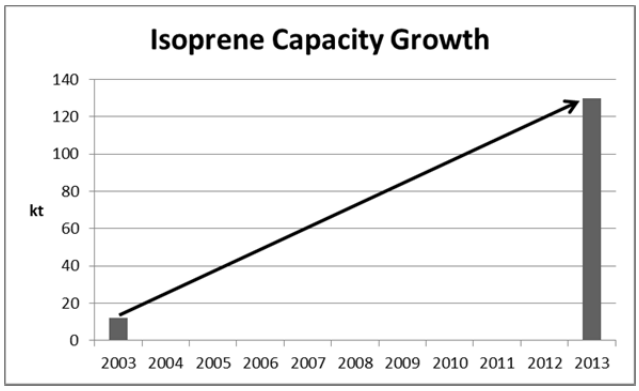


The current and future production of C5 HCR will be driven by feed availability. While feed availability to make C5 HCRs is contracting in the rest of the world, in China it is increasing. This expansion is being driven by a rapid expansion of naphtha-fed ethylene production, the source of piperylene feed. This chart shows the rapid ethylene capacity expansions in China.

The chart shows continual expansion beyond 2015, but may be limited by lower cost capacity expansion in other regions.

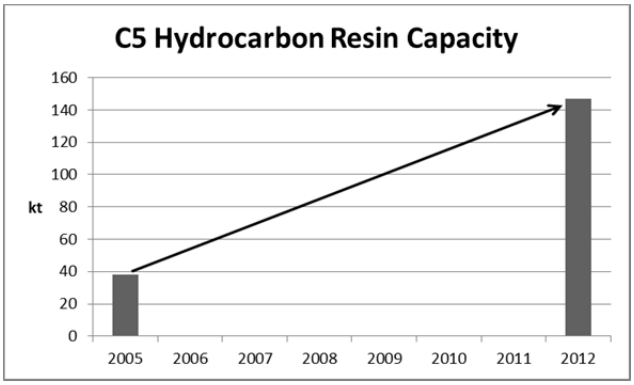
The ethylene unit provides the opportunity to recover and purify C5 HCR feed, which are called piperylenes. To recover this feed, one has to also install an isoprene purification unit, as piperylenes are a byproduct of isoprene purification. So in addition to the ethylene expansions, we need isoprene purification capacity expansions. The graph below shows the isoprene expansions in China over the last ten years. To put this in perspective, all of the piperylenes produced are getting close to being equal to demand. Especially with the decline in supply due to lighter feeds to their ethylene units.

Based on planned new isoprene purification capacity the amount of piperylenes in Asia will double in the next five years. This is in stark contrast with the other regions, where feed supply is constant or decreasing.



So, just based on feed, China is positioned to produce significantly more C5 HCRs. The critical question is: will it meet Western World quality standards for HMPSA applications?

C5 HCR capacity expansions in China have followed ethylene/piperylene feed availability over the last seven years as shown in the graph. In 2005 there were only two major producers (>10 thousand metric tons) and a few other small batch producers. In 2012, there are 12 major producers with average capacity of 12 thousand metric tons. This is in contrast with Western World where the average capacity is 40 thousand metric tons. In spite of the capacity increase, there was only one producer in 2012 with marginal quality relative to Western World standards



As capacity in China changed, so did the product quality, with each new unit making improvements in hardware, process technology and feed preparation. This has led to a continuous improvement in quality over the last 5 years.

The first change was the purity of the feed. Technology for upstream feed purification units improved. They now removed components in the feed that led to dark color, broad molecular weight and incompatibility.

Further, these new companies generally produce their own feed under a long-term supply agreement for the crude stream they purify. Also, the feed stream comes from a major ethylene producer(s). This removes any uncertainty on feed supply that other regions of the world have experienced

Next, they moved to larger, more continuous units, run by computer control. These are now continuous units with sophisticated computer control that now limit the batch-to-batch variation, which is very important to tape producers. These units were not only larger, but had improved technology where they had continuously fed and metered catalyst addition. More controlled neutralization, wash and settling systems that didn't leave residual spent catalyst in the product and didn't deteriorate the product coming out of the reactor.

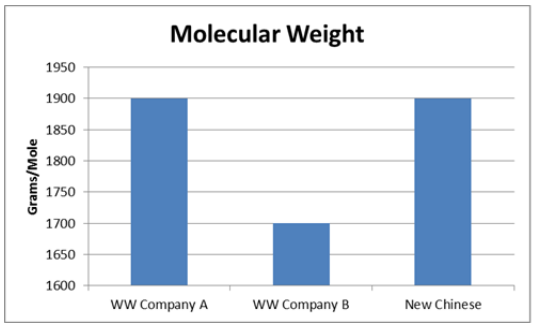
As mentioned earlier, historically the size of most units were small with some even being batch operations. Over the last five years the size of the units is more like 20k tons, or 44 million pounds. To build a unit like this requires more sophisticated technology, as the owner is risking 10s of millions of dollars to build this unit. With so much at stake for the owner, it is very important to make products the market requires and needs.

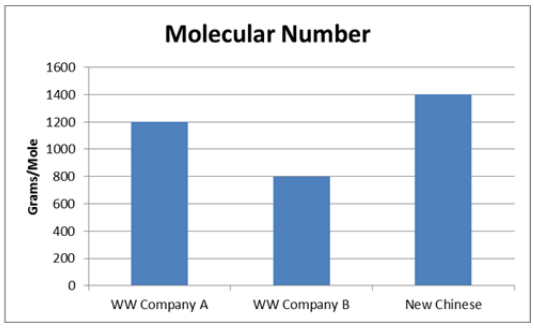
Now having better feeds, larger continuous units with improved control product quality is starting to improve. One producer, is now being used into some hot melt applications and being looked at in some pressure sensitive applications. Where the product is being used today is on an ad-mix basis and not used as the sole tackifier resin. This starts to show the progress made in Chinese tackifier resins penetrating higher end adhesive applications.

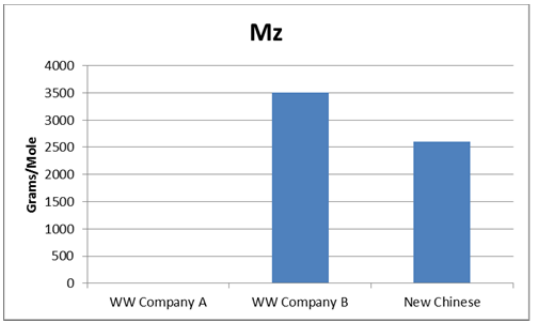
Now another C5 tackifier resin producer is starting up who is targeting to make Western World quality for pressure sensitive adhesive applications. The product quality targets for this unit are now approaching full Western World quality.

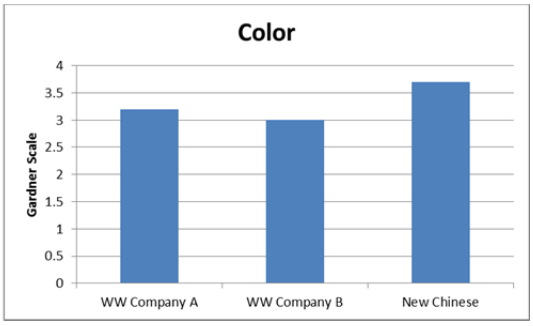
Shown below is a comparison of typical Western World quality against quality expected from the most recent capacity addition. Two grades are shown, a straight aliphatic grade and an aromatic modified aliphatic resin grade.

Pure C5 Aliphatic resin expected parameters

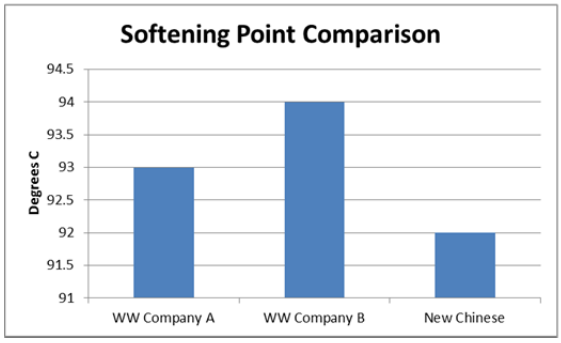


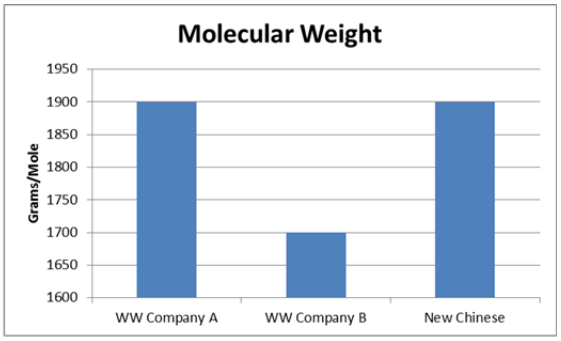


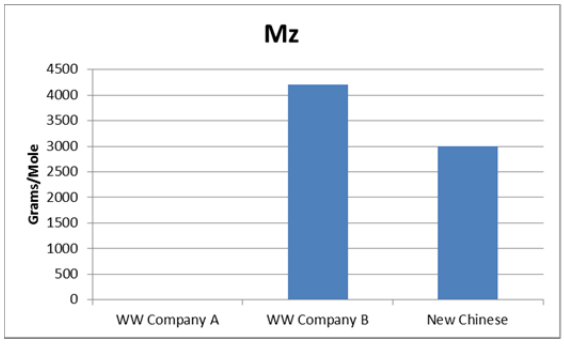


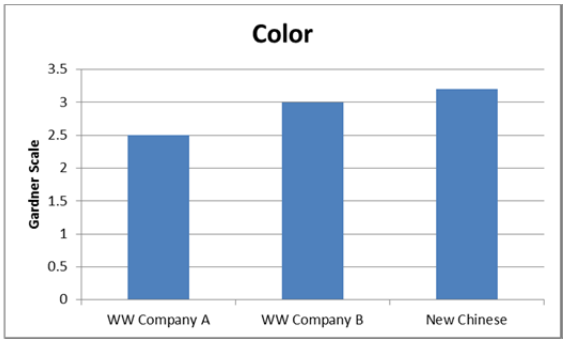


Aromatic modified C5 tackifier resin









The Chinese product in each case shown above is very close on all key parameters to Western World product.

In conclusion, this presentation was meant to give you a perspective on the progress in making high quality C5 tackifier resins in China, suitable for the pressure sensitive industry. And, the potential for future supply from our region to meet your growing demand.