EcoSynthetix' three pillar approach: Delivering economic feasibility - high performance - sustainability advantages

By **Peter van Ballegooie**, VP Marketing & Business Development, **Steven Bloembergen**, Executive VP Technology, **Phil Greenall**, VP Global Sales – Paper, **Ralph DeJong**, Director Customer Solutions, EcoSynthetix Inc.

ECOSYNTHETIX is a global supplier of innovative biopolymers that are applied across a diverse and wide range of industries, including paper and board, architectural coatings, adhesives, carpet backing and others. Headquartered in Burlington, Ontario, the company was founded in 1996 with the goal of developing high-technology, biobased materials that would deliver performance capabilities equal to or superior to those of traditional petroleum-based products, while also offering significant carbon footprint reductions.

From the beginning, EcoSynthetix established concrete goals for increased sustainability through the displacement of petroleum-based products in the marketplace to benefit humanity and the planet. However, we learned very early in our development that such "ideal world" goals would require "real world" solutions that encapsulate many other factors.

We could not achieve success on the merits of environmental benefits alone. We apply three critical drivers in support of our business growth objectives, regardless of market: economics, performance and sustainability.

Being a global supplier requires experience to meet the various challenges in exporting hi-tech products around the world. Each geographic location has its own unique government regulations and requirements, so it is imperative that we understand and address all of the key market drivers pertaining to our unique green chemistry. In doing so, we work with our customers to turn challenges into opportunities, and opportunities into success stories.

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With substantial investment in research and development, we are able to rapidly and efficiently develop products with performance characteristics that match or enhance the incumbent petrochemical technologies. In addition, we offer stable, competitive pricing that is not impacted by the volatility of the oil markets. Factor in the immense carbon footprint reduction benefits, and this three pillar approach becomes a compelling solution to many industries. Who would refuse an offering that provides superior performance benefits at a lower total cost while delivering significant sustainability advantages?

EXTENSIVE INDUSTRY EXPERIENCE

Critical success factors for global operations are reputation, experience and expertise. EcoSynthetix continues to experience rapid growth and has solidified its direct sales force by recruiting some of the most experienced industry leaders available. A global senior sales team with over 200 years of combined experience in the chemical, paper and refining industries amongst others, leads a global contingent of technical experts and specialists, providing our customers with state-of-the-art

ECOSYNTHETIX: DRIVING GROWTH THROUGH INNOVATIVE TECHNOLOGY

- **ECOSYNTHETIX features its rapid new product prototyping capabilities[1] at its global Center of Innovation and corporate headquarters located in Burlington, Ontario, Canada.**
- **Our strong patent estate is the foundation of the company's two technology platforms: EcoSphere® biolatex® polymers and EcoMer® sugar-based macromers.**
- **EcoSphere® biolatex® binders are being rapidly adopted and commercialized in paper coating applications in Asia, Europe and the Americas; most of the top-20 global coated paper manufacturers are now either using or trialing our technology in their global commercial operations.**
- **Manufacturing facilities in North America and Europe now have total annual production capacity exceeding 100 thousand metric tons.**

Table 1. *Coating Colours used for Low to High Shear Rheology Study*

Coating Color Sample #	1	6	7	8	9	10
Coating Description	XSB + CMC	50% Bio-A	50% Bio-B	50% Bio-C	50% Starch	XSB Only
Pigments						
GCC Hydrocarb 90	70	70	70	70	70	70
Clay, Fine No. 1	30	30	30	30	30	30
Binders						
XSB Latex (Prostar)	10	5	5	5	5	10
Bio-A	0	5	0	0	0	0
Bio-B	0	0	5	0	0	0
Bio-C	0	0	0	5	0	0
Starch (T&L 2015)	0	0	0	0	5	0
Additives						
CMC	0.5	0	0	0	0	0
Ca-Stearate	0.25	0.25	0.25	0.25	0.25	0.25
Solid Content, %	66.7	66.8	66.9	66.7	66.8	67.0
pH	8	8	8.1	8.1	8.2	8
Brookfield [mPa.s], 100 rpm	2460	2000	1150	520	1450	1170
Capillary Viscosity ($600,000\ s^{-1}$) [mPa.s]	64	111	91	73	112	52
Slit Viscosity ($1,900,000\ s^{-1}$) [mPa.s]	44	63	43	36	55	35

technology, regional knowledge and competent support. With a robust customer support infrastructure in place, we are fully equipped to meet the specific challenges of each region.

EcoSynthetix continues to build a strong portfolio of solutions ranging from our flagship EcoSphere® biolatex® binder products to our emerging EcoMer® biobased platform. By focusing on the three key drivers of economics, performance and sustainability advantages, EcoSynthetix will continue to diversify its presence in a multitude of industries from building products to personal care while expanding its reach into the pulp and paper market with new grades and value-added solutions.

TECHNOLOGY LEADERSHIP

As the paper industry continues to evolve in 2013, it is simply not enough to provide new technologies that are considered novel or disruptive. There have to be compelling, value-added elements that are not only beneficial to the producer of the technology, but ones that can be passed along the value chain of the industry as a whole. From recent research by EcoSynthetix along with the Department of Paper Engineering, Chemical Engineering and Imaging, Western Michigan University, and Department of Nanotechnology Engineering, Waterloo Institute of Nanotechnology, we now have even more supporting evidence that EcoSphere biolatex binders can significantly broaden the performance envelope in our customers' manufacturing operations.

A latex can be defined as a stable suspension of colloidal polymeric particles. Lab studies[2] were carried out to establish a number of similarities and differences between binders including EcoSphere biolatex binders, styrene butadiene-based latex and conventional cooked soluble starch. Note that such coating starches, used as co-binders in coated paper manufacturing, are solutions and not colloid particles. The work performed included rheological experiments. Low shear viscosities were obtained using a TA AR-2000 Stress Rheometer with double concentric cylinder geometry. Intermediate shear rate rheology was evaluated with a Hercules rheometer. High and ultra-high shear rates were studied with ACAV A2 Ultra-High Shear capillary and slit rheometers. The latter two devices can mimic actual high and ultra-high shear conditions of modern high-speed rod and blade coaters that are commonly experienced in the coated paper and board industries.

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For this work, standard coating formulations were prepared (see Table 1), where 50% of a Styrene-Butadiene-Acrylonitrile (XSB) latex binder was replaced with either a conventional cooked coating starch or an internally crosslinked EcoSphere biopolymer latex, with samples Bio-A to Bio-B to Bio-C ranging from relatively low to medium to high internal crosslinking. As shown in Figures 1A and 1B, one cannot accurately predict performance on the coater based on low shear viscosity measurements.

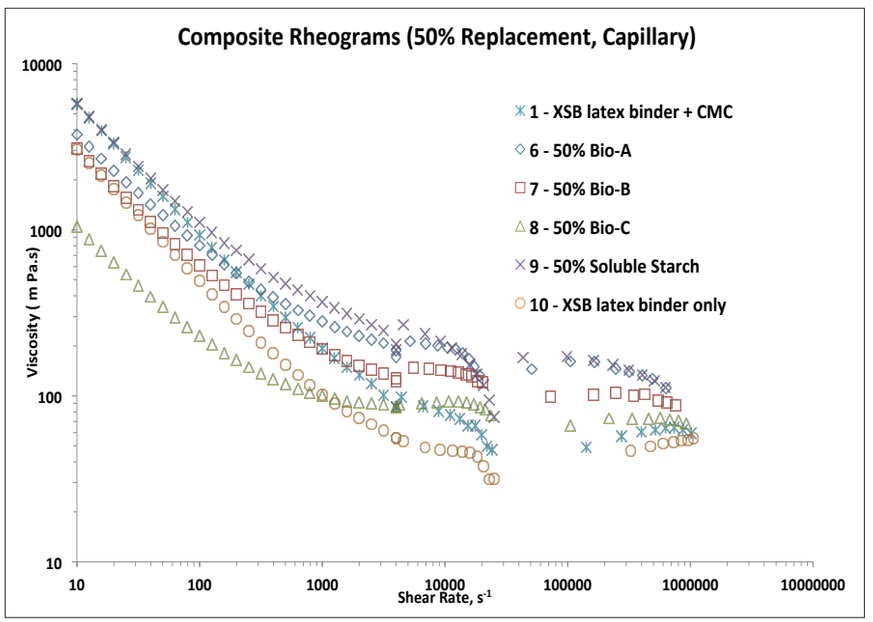


Figure 1A. *Composite rheogram for coatings in Table 1, showing the compilation of shear profiles from low shear (capillary viscometer), to moderate (stress rheometer), to medium (Hercules "high" shear rheometer), to high shear (ACAV capillary rheometer)*

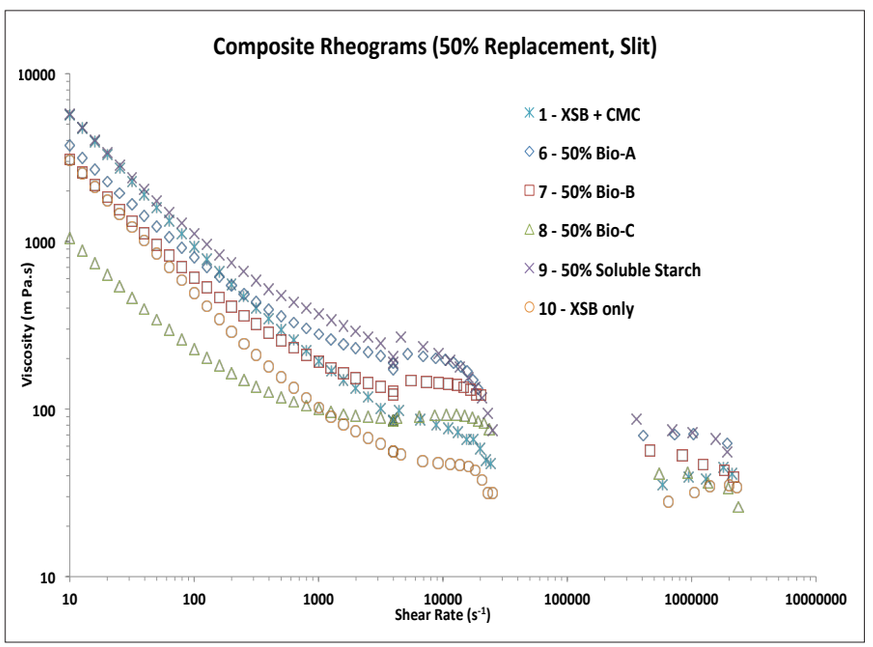


Figure 1B. *Composite rheogram for coatings listed in Table 1, showing the compilation of shear profiles from low shear (capillary viscometer), to moderate (stress rheometer), to medium (Hercules "high" shear rheometer), to ultra-high shear (ACAV slit rheometer)*

The overall performance can be comparable to "all-synthetic" latex systems, and is far superior to conventional cooked coating starches

Unlike conventional cooked and soluble starch solutions, EcoSphere biolatex dispersions are colloids that consist of internally crosslinked particles. With increasing intra-particle crosslink density, these biobased colloids have been found to behave much like petroleum-based synthetic latex colloids. Thus, the overall performance can be comparable and even superior to "all-synthetic" latex systems, and is far superior to conventional cooked coating starches. Figure 2 expands the ultra-high shear region of the highest shear device used in the industry to predict coating performance (that is, using the ACAV slit rheometer). Looking in greater detail at the ultra-high shear region in Figure 2, it can be observed that the ethylated starch and low crosslinked EcoSphere Bio-A grade display rheology behaviour that is insufficiently shear thinning; with the medium to high crosslinked Bio-B and Bio-C EcoSphere grades, however, shear thinning is down to (and beyond) conventional XSB performance. In fact, at ultra-high shear the XSB is showing dilatency (that is, an increase in viscosity with increasing shear rate)

which is likely due to agglomeration of hard particles. By comparison, a 50% replacement of the XSB with Bio-B or Bio-C results in superior coatings displaying a continuously shear thinning pattern. We discovered that this is also the case even at 30% replacement levels[2]. Note also, that coating number 10, without rheology modifier/thickener, would normally not run well on a commercial coater. This coating simply has insufficient water holding capability. The dynamic water retention of these coatings was recently studied, and the results will be presented at the PaperCon conference in Atlanta, Georgia (USA), April 28 - May 1, 2013.

It has generally been found that, from a pure shear thinning and water holding perspective, the internally crosslinked biopolymer latex binders have excellent water retention performance, in addition to being more shear thinning than the petroleum XSB latex binders. This can explain the superior runnability consistently observed for these biopolymer binders in high speed coated paper and board trials observed in mills worldwide. Other findings conclude that our biolatex colloid particles achieve the maximum swelling value under conditions of extreme dilution with water.[3] Secondly, they de-swell with increasing solids so that their dispersions can be made at higher solids.[3]

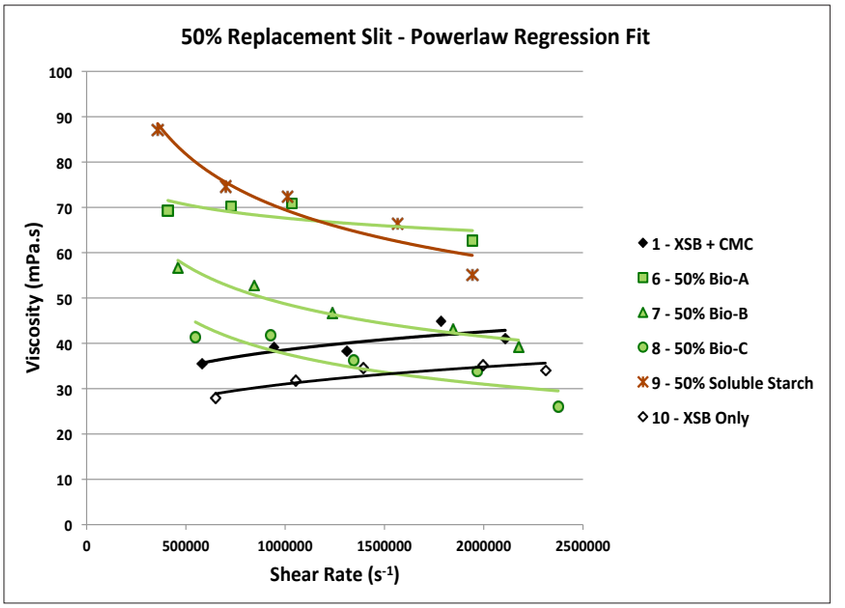
While traditional soluble cooked starch polymers can form a "particle-like" random coil in solution at very low shear, they become chain extended and linearised as shear increases, resulting in the loss of water retention and shear thinning characteristics. This is why soluble polymers cannot perform as effectively as colloid particles such as petro-based latex and internally crosslinked EcoSphere biolatex colloid particles.

The water-swollen particles in EcoSphere deform and de-swell under shear and pressure, which is a unique property of our technology. When stress is applied to the fluid, the biolatex colloid particles start deforming in the coating color. It is proposed that the swollen biolatex colloid particles, when exposed to high shear, are compressed and release water, thereby decreasing the effective solid volume fraction at which time they begin to act as a lubricant and allow better particle alignment. This is depicted schematically for a biopolymer latex in Figure 3A and for an "all synthetic" petroleum-based latex in Figure 3B.

With ever more internal crosslinking of the biolatex particles, a significant decrease in viscosity at ultra-high shear rates occurred. Thus, EcoSphere biolatex binders – in principle – may outperform conventional cooked coating starches as well as "all synthetic" petro-latex binders in terms of fundamental rheological properties and commercial high speed coater runnability.

Further testing has been conducted by Western Michigan University on Static Water Retention Compared to Dynamic Water Retention of Coating with Varying Thickeners and Temperatures.[4] This work was presented at the PaperCon2012 conference. An extract from this paper is as follows: "The dewatering of paper coatings and water penetration into the base sheet are well known phenomena

Figure 2. *Ultra-high shear rheogram measured on an ACAV slit rheometer for coatings listed in Table 1.*



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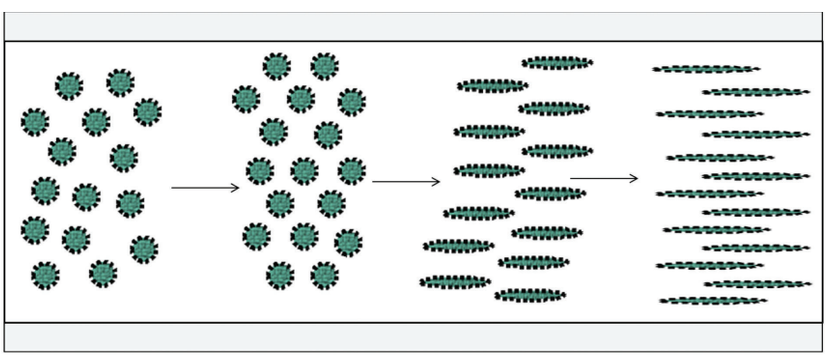

Figure 3A. *Proposed model for rheological performance of internally crosslinked biopolymer latex colloid particles under increasing shear conditions.*

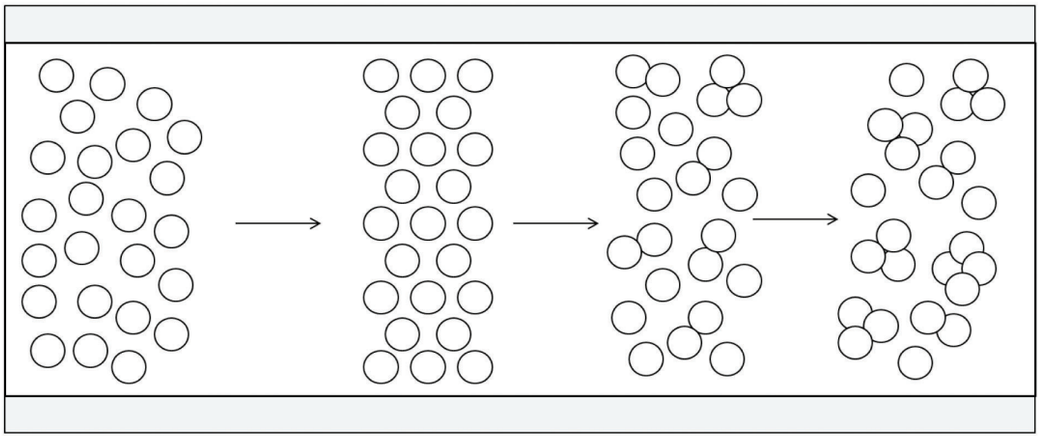

Figure 3B. *Proposed model for rheological performance of petro-based XSB colloidal latex particles under increasing shear conditions.*

influencing the runnability of a paper machine coater. The most frequently observed effect of coating dewatering is an increase in recirculated coating solids with time. Under drastic dewatering, the runnability of a coater can be impaired, resulting in scratches, streaks, and whiskering problems." The research studied the influence of thickener, binder type, and temperature on coating dewatering. Under testing, the rate of dewatering was slowest with the EcoSphere biolatex binder products. Thus, water was released more slowly into the base sheet for improved runnability.

The research is indeed compelling. The combined research reported at the TAPPI 2012 PaperCon venue, along with the latest collaborative R&D findings that are to be presented at the 2013 PaperCon forum, demonstrates that EcoSphere biolatex binders have unique rheological properties and superior dynamic water retention capabilities that offer improved performance. We have a product offering that is uniquely well-supported by the three key pillars that enable delivery of at-least-equal performance to petro-latex incumbents at an overall cost saving, while providing unmatched sustainability advantages. Our biopolymer colloid particles open up a new performance envelope that goes far beyond the capabilities of conventional cooked and liquid starches. Consequently, when one is looking to optimise binder performance with processing runnability and economic considerations, EcoSphere biolatex binders provide an excellent alternative to both synthetic petroleum-based and conventional starch-based latex products.

LOOKING FORWARD INTO 2013

With the paper industry facing increasing global competitiveness pressures, it is paramount that manufacturers continue to address the evolving market needs and embrace new technologies that can combine both improved performance and economic benefits. Most of the top-20 global coated paper manufacturers are now either using or trialing EcoSphere in their commercial production operations. With our investment in regional sales and technical service support, EcoSynthetix is very well poised with its biolatex® polymer offerings that deliver solutions to these needs, while simultaneously providing opportunities for developing a more sustainable future for coated paper and board producers. In addition, our customers can rest assured that our continued investments in our state-of-the-art R&D and manufacturing facilities, located in Ontario, Canada, in Brabant, The Netherlands and in Tennessee, U.S.A. will continue delivering new product innovations meeting the highest quality assurance standards.

None of these challenges, however, can be successfully resolved without having positive collaboration and teamwork between EcoSynthetix and the most important part of the whole value chain – the customer. Whether your goals are cost savings, improved performance or reducing your carbon footprint, it would be a pleasure to work with you. Visit us at **www.ecosynthetix.com** or contact your local EcoSynthetix representative for further details.

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