Buckman Maximyze Technology

Presidential Green Chemistry Award 2012

**Introduction of Buckman Chemical**

Buckman Chemical was founded by Stanley J. Buckman in 1945.  The company started with four employees in Memphis, Tennessee and has grown under the leadership of the current CEO Bob Buckman to a global business with more than 1500 employees.  Buckman is a specialty chemical company that develops new chemical technologies for other corporations to improve their production by minimizing water usage, energy consumption, pollution, and waste.  Buckman manufactures 800 different products, and the company’s revenue in 2012 was $624 million. The headquarters is still located at the 350-employee research and development facility in Memphis, Tennessee.1

60% of Buckman Chemical services the pulp-and-paper industry by finding ways to improve paper fibers using enzymes, to streamline wet end performance, and to enhance paper properties.  In 2004, Buckman received the Presidential Green Chemistry Challenge Award for its Optimyze technology, which is an enzyme that removes sticky contaminants from paper mill machinery.  Optimyze reduces the amount of hazardous solvents used by 600,000 pounds per paper mill per year and also increases production .2  Buckman also assists the water treatment industry by developing technologies that increase production efficiency by treating microorganisms that cause fouling.  The company also works with leather making corporations to develop enzymes to enhance wet blue processing and to manufacture finishing applications to boost leather performance.  Additionally, Buckman makes performance chemicals for the following industrial sectors: agriculture, biofuels, coatings and plastics, metalworking, oil and gas, recreational water, rubber, textile, toll manufacturing, and water treatment.3

In 2012, Buckman won its second Presidential Green Chemistry Challenge Award, this time in the Designing Greener Chemicals Award category.  The award was given to Buckman for its Maximyze enzyme technology.4

**Green Chemistry Award Technology**

Maximyze technology provides advancement in the paper and packaging industry.  Maximyze enzymes alter the cellulose that is present in wood to increase the number of wood fibers that can be bound together.  The result of this improved binding is better paper quality and strength through a more environmentally friendly process.  In the past, to make strong paper would require chemical additives, expensive wood pulp, and treatment that required large amounts of energy.  By using the Maximyze enzymes, these costs can be avoided.4

The Maximyze technology makes use of enzymes developed from natural and renewable sources through a fermentation process, avoiding the use of chemical additives like glyoxalated polyacrylamides and polyacrylamide copolymers.  The energy consumption of the refining treatment process is reduced since the paper drains faster (reducing the required amount of steam) and there are less electricity requirements for the new process.  Since the strength of the paper is improved, the product can be created with greater amounts of recycled paper or filler rather than utilizing the expensive wood pulp.4

The technology fits in line with the company’s product portfolio.  Buckman works to create chemical technologies that other companies can use to improve their production through sustainable practices, and the Maximyze technology epitomizes this goal.1  In 2011, a pulp and paper manufacturer started to add Maximyze enzymes to its pulp, and the addition increased production by 2% and decreased the amount of refining required by 40%.  It also reduced the density of the paper by 3 pounds per 1,000 square feet while still meeting the same quality standards.  These reductions for this one machine can be expressed as saving 25,000 trees per year.  Another mill has also saved $1 million per year with the addition of Maximyze technology to its process.4

The environmental and economic sustainability impact on society is clear from these examples.  The paper and packaging industry has a workforce of around 400,000 people and products sales of $115 billion per year, so advancements in this industry have a significant impact on the economy of the United States.  The technology has expanded and is now being applied in over 50 paper mills in and outside the U.S.4

The efficacy of the Maximyze enzyme method for improving paper strength can be evaluated using Level 1 metrics.  A common way for the paper industry to enhance paper strength is by using chemical additives, like polyacrylamides.  The mass of chemical additives required to treat the paper is about four times as much as the mass of Maximyze enzyme - 1260 mT/year of chemical additives compared to 315 mT/year of enzymes.  Consequently, there is much less waste generated from the use of enzymes compared to the amount of waste generated by the use of chemical additives, so the E-Factor is lower for the former process.  Furthermore, the enzymatic waste is not hazardous, so the Effective Mass Yield is higher for the Maximyze method.  Other metrics, like Atom Economy and Reaction Mass Efficiency, are difficult to determine since the reaction pathway is not clear.  Based on the relevant Level 1 metrics, it is apparent that using the Maximyze enzyme is preferred since less waste is generated and the waste is not as hazardous.5

Level 2 metrics also confirm that the Buckman technology is superior to using polyacrylamides.  Polyacrylamide is a somewhat volatile chemical with a vapor pressure similar to that of water, so there will be fugitive emissions of polyacrylamide throughout the paper mills.  This means that some of the polyacrylamide will be wasted due to these emissions, and the emissions also pose a health hazard since polyacrylamide is moderately flammable (flash point >93 °C) and may cause respiratory tract irritation if inhaled.  On the other hand, the Maximyze enzyme is not volatile, so fugitive emissions are not a concern.  Additionally, there are hazards associated with storing polyacrylamides.  If storage vessels fail, it is possible that the polyacrylamides could enter the water system or pose a threat to operators.  The Hazardous Materials Identification System assigns a health rating of 1 to polyacrylamide.  The acute oral toxicity is given as LD50 > 20 mL/kg (rat), and the acute inhalation toxicity is LC50 2.44 mg/L for 4 hours (rat).  Although polyacrylamide is not expected to bioaccumulate, it still presents a hazard to fish, aquatic invertebrates, and microorganisms at higher concentrations.  The Maximyze enzyme does not pose these risks, and therefore, it is a better technology than chemical additives.6

Level 3 metrics can also be used to evaluate the effect of the Maximyze technology on the paper production process.  A Life Cycle Assessment can be performed where the goal is to compare the environmental impact that using or not using Maximyze enzymes has on the production of a certain quantity of papers from cradle (considering the inputs into the paper production process) to gate (when the paper has been produced).  There are some key differences in the Life Cycle Assessment of paper depending on whether Maximyze enzymes are used or left out.

In the inventory analysis step, key data can be taken on factors such as health impacts of reactants used, global warming potential, and energy intensity.  Then, in the impact assessment step, the data can be organized and grouped into categories.  In this step, it would become apparent that in the energy intensity category, the quantity of tons of steam per ton of paper was reduced from 2.23 to 1.86 with Maximyze.7  Also, in the global warming potential category, carbon dioxide emissions for  transporting a 20 mT load was reduced from 13.1 to 3.3 mT per year per 100 kilometers travelled.5  Finally, in comparing the human and environmental health impacts, it would be apparent that the Maximyze enzymes are made using renewable raw materials in a fermentation process and are completely biodegradable, while without Maximyze enzymes, the chemical additive polyacrylamide must be added, which can irritate the respiratory tract and skin.6

In the interpretation step, it may be concluded that the process using Maximyze enzymes is greener on a life cycle basis since in the categories analyzed, that process used more environmentally healthy reagents, reduced energy intensity, and had less global warming potential.

The Principles of Green Chemistry are another tool for characterizing the impact of using Maximyze enzymes in paper production.  The principles that this technology illustrates are waste prevention, design for energy efficiency, use of renewable feedstocks, and inherently safer chemicals for accident prevention.  The waste prevention principle is achieved since the mass of enzymes used to increase the strength of the paper is less than the mass of the chemicals additives used for this same purpose, meaning there is also less waste used in the process with Maximyze enzymes.  Then, as previously mentioned, the new process is a way of designing for energy efficiency since it cuts down on steam and electricity usage, and the use of renewable feedstocks is met since the enzymes are created from renewable materials.  Lastly, inherently safer chemicals for accident prevention is met since the process utilizing Maximyze technology eliminates the need for chemical additives which react negatively with the human body to be stored at the paper mills, reducing the chance for there to be a spill or leak and therefore human contact with the chemicals.

In conclusion, we believe Buckman was a deserving winner of the Presidential Green Chemistry Challenge Award in 2012.  The paper and packaging industry is an important sector of the U.S. economy now, and it will remain so in the future.  It is therefore crucial that technologies be implemented into this industry to allow it to be sustainable in both an environmental and an economical sense.  Buckman has accomplished this challenge with its Maximyze technology.  As previously discussed, using Maximyze enzymes made the previous paper production process greener by eliminating the need for hazardous chemicals, decreasing energy intensity, and reducing waste.  However, the technology also improved the economic sustainability of the paper production process, making it possible for a plant to save around one million dollars per year by implementing the technology.  We were able to apply many green chemistry metrics and principles to evaluate the Maximyze technology, and we were impressed by the far reaching impacts the technology had.  If the technology can save wood pulp equal to approximately 25,000 trees per year at one plant, it can have a significant impact on the consumption of wood pulp as it is applied in 50 more paper mills.  Overall, we believe the Maximyze technology is an excellent innovation that should be implemented in more paper mills in the future.

Below is the response we received from a Buckman employee regarding the Presidential Green Chemistry Challenge Award:

Thanks for communicating with us on this subject. You may inform Dr. Kitchens that he may use this information in his course materials if he thinks it will be useful.

If you do a little more research you will discover that this is the second Presidential Green Chemistry Challenge award that has been awarded to our team. Both awards are in recognition of successful application of enzyme technology in an important heavy industry (the paper industry).

Our first PGCC award was for an enzyme that facilitates the process of recycling paper products. It improves the production of new paper products from recycled paper by acting on components of recycled papers (glue-like materials). It has been widely used in paper mills for almost 15 years now. So it is the use of a green material (an enzyme) that replaces petroleum-based materials (not green) to expedite recycling (green!).

I’d like to put in a word for the paper industry, a group that maybe doesn’t have a great reputation as being an environmentally friendly industry. In fact the paper manufacturing industry is one of the most sustainable. There aren’t many segments of industry where (1) its raw material is completely renewable (for every tree used by this industry 3-4 are planted) or (2) well over 60% of their product is recycled (true for paper) and (3) also a significant converter of biomass to energy.

Now I’ll get to your questions.

**What has your development of this technology meant to your company?**

If you do some research on this subject, you will find that pretty much every consumer is in favor of more recycling and more green products, but in fact very few people are willing to pay more for an equivalent product just because it is ‘green.’ This is true for businesses as well.

Another factor is this: any new product must provide for one’s customer a return that is more than its cost (that’s common sense).

We always strive to produce sustainable, renewable, environmentally friendly technologies. But to be viable those products must provide a significant return for both my customers and my company.

The products that have been given this award continue to be successful. They provide a benefit to our customer many times greater than the cost, and they are profitable for my company as well. In addition, our company has the motivation to be good citizens in the communities we are part of around the world. We fulfil that goal by providing greener products like this.

**When you began working on this technology, what were your motivating factors and was green chemistry or green engineering a part of your mindset?**

I may have dealt with most of this in the previous answer. Our motivations include these:

-      the person satisfaction of creating a successful new product

-      differentiating our company from the competition with unique products

-      being good citizens

-      solving important problems for our customers

-      making our company profitable and sustainable

Creating products that are greener is very definitely a motivating factor for our company.

Enzyme technology, which was novel at the time we introduced it (and not simple to put

into practice), fits into our goals very well. Enzymes are (1) renewable (2) biodegradable

(3) good from safety & environmental viewpoints and (4) not petroleum based. Then, too,

we can work with a huge variety of enzymes exist in nature.

**Has developing this technology or winning this award influenced your professional outlook, personal goals, or definition of success?**

The list of motivators given above would keep us working hard. However, the award is another impetus, and also a reward. I don’t think it has changed anyone’s outlook or goals, nor definition of success. But we keep it in mind. Just today we discussed which current projects have a good chance of winning another PGCC award.

**What has being awarded the PGCC Award meant to your company and how has it influenced your career?**

Buckman works very hard around the world to improve the communities in which we work and live, and an award like this shows the company to be a good citizen but also is a motivation to continue that sort of work.

The PGCC awards are mentioned many many times, in presentations to customers, in advertisements, in many other venues. There is an ongoing benefit to the company in many ways.

For one’s career, when you apply for and win such an award it can’t hurt! The positive publicity the award provides benefits the company in many ways. Those who own and/or manage the company

**Are there any professional experiences related to green chemistry or green engineering that you would like to share?**

It was a great experience to go to Washington with our team to receive the award, and to meet with major players in industry and at the EPA, to present one’s winning technology and to discuss it with one’s congressman.

**Do you have any advice for a young chemical engineer beginning a career in industry?**

Everyone should have in mind at all time wise use of resources and careful stewardship of the earth. So ‘green’ chemistry is crucial. And note that sustainability is not just an environmental issue. A company must be economically sustainable too. That ensures continuing benefit to their customers. That guarantees jobs for their employees, and continues benefits to the community for example by tax revenue. To maintain that sort of sustainability requires the production and use of many “non-green” products as well.

A young chemical engineer should include a broad set of experiences as part of his or her learning. Real-world experience and training are crucial to putting all aspects *sustainability* into a context.

Best regards.

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References

1. Arnold, Ed. The Business Journals: *Buckman got personal, environmentally friendly to aid clients*. <http://www.bizjournals.com/bizjournals/how-to/growth-strategies/2012/09/buckman-got-personal-environmentally.html?page=all>. 18 October 2015.
2. EPA: *2004 Greener Reaction Conditions Award.* <http://www2.epa.gov/greenchemistry/2004-greener-reaction-conditions-award>. 18 October 2015.
3. Buckman. <https://buckman.com/en>. 18 October 2015.
4. EPA:  2012 Designing Greener Chemicals Award.  <http://www2.epa.gov/greenchemistry/2012-designing-greener-chemicals-award>.  18 October 2015.
5. Denowski, Dan; Hoekstra, Phil. A greener alternative for improving strength in recycled packaging. *TAPPSA,* **2013**, *Volume 1.* <http://www.tappsa.co.za/html_index_links/html_issue_1_2013/feature1_packaging%20chemicals.pdf>. 18 October 2015.
6. *Parez1000LS.* Kemira Chemicals, Inc: Kennesaw, GA. 7 September 2007. <http://www.sfm.state.or.us/cr2k_subdb/MSDS/PAREZ_PP_DRY_STRENGTH_RESINS.PDF>.  18 October 2015.
7. ACS.  Green Chemistry Case Studies: Presidential Green Chemistry Challenge Awards 2012 Winners, 2012.