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Environmental assessment of next generation blowing agent technology using Solstice LBA in ccSPF

As green designs and considerations have evolved, the environmental impact of materials has become a factor in material selection criteria for design professionals. One environmental consideration is the Global Warming Potential (GWP) of materials. As a result, for closed cell Spray Polyurethane Foam (ccSPF), a Low Global Warming Potential (LGWP) blowing agent is desired by various design professionals, architectural and consumer groups. Honeywell embarked on the development of a LGWP platform of products marketed under the trade name Solstice. Solstice Liquid Blowing Agent (LBA), with a GWP of < 5, has been developed as a LGWP solution for use in ccSPF applications as well as other foam insulation applications. To address the growing demand for product environmental data, the Spray Polyurethane Foam Alliance (SPFA) recently completed a Life Cycle Analysis (LCA) for spray polyurethane foam insulation which conformed to the internationally recognized ISO 14040/44 standards. This study is the first comprehensive LCA of spray foam insulation conducted in North America and evaluated both open cell and closed cell SPF products. To expand on the SPFA study, Honeywell repeated the study and substituted data for Solstice LBA as a replacement LGWP blowing agent in the application.

1. Introduction

For residential, commercial and institutional buildings, sustainability has increasingly become a highly important project driver and design criteria factor. Key attributes associated with high-performance and green building designs include high energy efficiency, occupant comfort, and material durability which ultimately translate to increased property values. The advent of green building standards and more stringent code requirements have led to the adoption of best practices in construction materials use, specification and methods. Among these is the use of more efficient insulation systems, air barriers, and seamless monolithic roofing systems. One such system, ccSPF insulation, has proven to be a versatile and effective means for achieving the stringent requirements of modern energy efficient construction standards. ccSPF insulation has been shown to offer superior thermal and moisture control of the building enclosure for several decades and has gained significant attention in recent years as an effective means for meeting more stringent modern building standards and consumer expectations.

There are many key factors to consider when selecting, specifying and designing a green or high performance insulation system. What separates ccSPF from alternative or traditional insulation materials is that it provides a combination of benefits to the building: excellent thermal protection, air barrier performance, water resistance and structural enhancements. One key component of ccSPF that contributes to many of these attributes is the use of a high performance blowing agent, with superior insulating properties, which is trapped in the closed cells of the foam.

As green designs and considerations have evolved, the environmental impact of materials has become a factor in material selection criteria for design professionals. One environmental consideration is the GWP of materials. As a result, for ccSPF, a LGWP blowing agent is desired by various design professionals, architectural and consumer groups. As a manufacturer of blowing agents with a commitment to the environment, Honeywell embarked on the development of a LGWP platform of products marketed under the trade name Solstice. This liquid blowing agent (LBA), which has a GWP of < 5, has been developed as a LGWP solution for use in ccSPF applications as well as other foam insulation applications.

From an environmental perspective, Solstice LBA represents a significantly better replacement for existing blowing agents. It exhibits certain key physical properties, such as boiling point, molecular weight, flammability, and Ozone Depletion Potential (ODP) similar to current blowing agents used in ccSPF applications. However, the GWP of Solstice LBA is markedly lower than that of currently utilized HFCs (245fa or 365mfc/227ea), and is more than 30 times lower than the present limitations in the EU F-Gas Regulation. Solstice LBA is also non-flammable, offering safety advantages over other blowing agent alternatives. This makes it uniquely suited to meet the stringent requirements of environmentally conscious designs, standards and codes while maintaining the high performance expectations of ccSPF that the design community, builders and owners have grown to expect.

Recent articles and trade journals have highlighted the GWP of products as a potential area for improvement and consideration in product selection. With a GWP < 5 and approval for use in foam insulation applications by the US EPA Significant New Alternatives Policy (SNAP), Solstice LBA offers a commercially ready, environmentally friendly alternative for maintaining the stringent requirements of high performance insulation materials such as ccSPF.

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2. Product environmental impact assessment

Of growing importance in the selection and use of a particular product is the overall environmental impact. To fully assess the environmental impact of a product, one must consider the overall impact of manufacture, service and disposal of the product. A common tool for evaluating this impact is the LCA and a common measure for this is the embodied energy (often expressed as carbon footprint) associated with that product. Although there are many ways to evaluate the carbon footprint of a product, the ISO 14040 series of standards are the current internationally recognized method for conducting an LCA. Because an LCA considers the full impact of manufacture, use and disposal, it is gaining momentum as the measure of environmental impact and selection criteria for products. The LCA comparison avoids pitfalls associated with current single attribute measures, which often do not provide a measure of true environmental impact. In fact, several countries in Europe have enacted LCA requirements and are experimenting with environmental footprint labeling programs. In addition, green rating programs are moving to a more comprehensive evaluation methodology such as the discrete product LCA, as well as an environmental payback and, eventually, a whole building analysis.

3. Assessment of ccSPF insulation LCA and Solstice LBA

To fully assess the environmental impact of a product such as ccSPF, one must consider all components of manufacture including raw materials, transport, use and disposal phases. **Figure 1** depicts the basic components of a comprehensive ccSPF LCA. Note that in the use phase, the benefit of energy savings attributed to ccSPF can be considered to offset any product environmental impact and for evaluating a net environmental payback associated with the product use.

To address the growing demand for product environmental data, the SPFA recently completed an LCA for spray polyurethane foam insulation which conformed to the internationally recognized ISO 14040/44 standards. This study is the first comprehensive LCA of spray foam insulation conducted in North America and evaluated both open cell and closed cell SPF products.

Specific to ccSPF, the SPFA analysis evaluated the environmental impact of using current ccSPF products in single family residential as well as commercial roofing structures in three different climate zones of the USA. ccSPF was evaluated using generic formulations and per typical US construction requirements in Houston, TX, Richmond, VA, and Minneapolis, MN. For commercial roofing applications, a retrofit of a roofing system in a typical 10,000 square feet (~930 m^2) strip mall application was considered. The roofing evaluation considered improving existing roof insulation value from R-4 and R-12 to an improved R-20 total per ASHRAE 90.1-2010 requirements. A 60 year project lifespan was assumed for the purpose of the study. The analyses pointed out the significant advantages that spray polyurethane foam insulation brings to the environment through energy savings and significant reduction in air infiltration. **Figure 2** summarizes the project evaluation scope.

To expand on the SPFA study, Honeywell repeated the study and substituted data for Solstice LBA as a replacement LGWP blowing agent in the application. Therefore, the assumptions used in the embodied energy and use phase of the Honeywell study are identical to those used in the SPFA study except for the data associated with the blowing agent. The study focused on GWP impact since this environmental impact criteria was determined most sensitive to the use of the blowing agent in the SPFA study. The study is conservative in nature because preliminary ccSPF evaluations with Solstice LBA have shown superior energy efficiency performance relative to current HFC technology, yet were not considered as part of the study.

What makes these studies unique and applicable to selecting and specifying an insulation system, is that they also evaluate the beneficial attributes for using ccSPF such as energy savings and air sealing. This is an important evaluation criterion because, according to the EPA, operational energy use of US homes and offices, including heating,

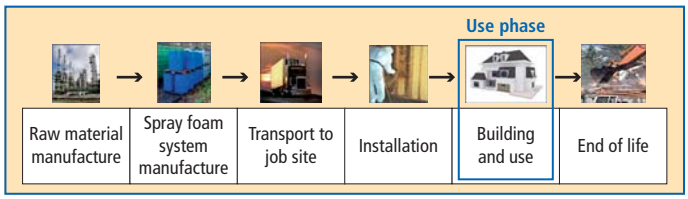


Fig. 1: *Basic components of an LCA for ccSPF*

Fig. 2: *Summary of project evaluation scope (Source SPFA)*

cooling, lighting and running electronics, account for 40 % of CO_2 emissions from fossil fuel combustion. To evaluate these benefits, energy savings were calculated for residential use with EnergyGauge, a Residential Energy Services Network (RESNET) approved software, and EnergyPlus software for the commercial roofing application. By considering these benefits as part of the product use, design professionals are able to make more informed decisions regarding the overall impact of a product selection such as ccSPF, with criterion beyond a simple embodied energy calculation.

4. Findings

The findings provided here focus on two main parameters of ccSPF containing Solstice LBA: the total embodied energy and GWP payback. The total embodied energy (carbon footprint) calculated by the study for residential wall construction was determined to have an average environmental impact of 185 lbs (84 kg) of CO_2 annually, based on the average of the three climate zones evaluated and the specific model homes evaluated. However, it is difficult to compare this value against other insulation materials. The issue is that not all insulations perform the same overall functions. As mentioned earlier, ccSPF is unique because it provides thermal insulation, air barrier performance, air sealing and structural enhancement all in one product application. These are the attributes that have made it so popular. Because ccSPF expands and seals during installation, it conforms to odd shapes and details to create an effective air barrier, in addition to providing insulating value. Air sealing is an imperative and integral step required for insulation to perform as designed. Traditional air permeable insulation such as fiberglass and cellulose require additional steps to create an air seal using caulks, sealants and air barrier materials, therefore a direct insulation system comparison with a simple product LCA is difficult to make against ccSPF.

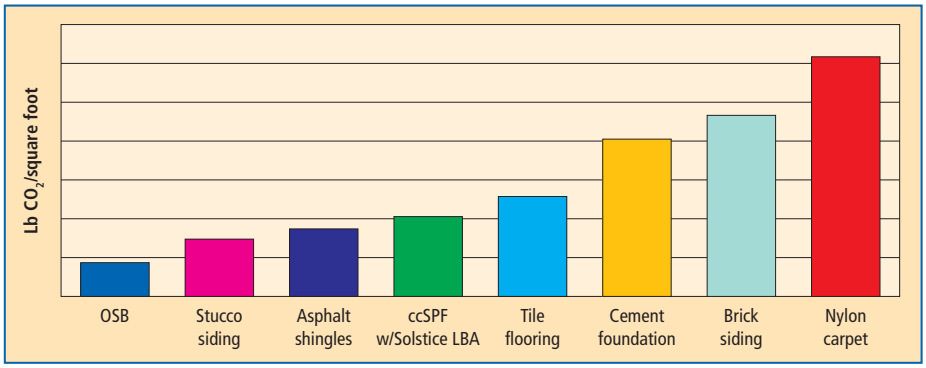
Figure 3 provides a relative comparison for the carbon footprint of general materials used in construction. The comparison data was drawn from the BEES database and shown by CO_2 equivalence per square foot. The relative impact of ccSPF with Solstice LBA was calculated and ranked based on the study results and shows that it has a relative lower impact compared to commonly used construction materials such as nylon carpeting or brick siding. In addition, the details of each individual product assumptions would need consideration as part of a true head-to-head product comparison, thus only a relative comparison can be made at this stage.

In addition to having a lower carbon footprint than commonly used construction materials, ccSPF containing Solstice LBA provides considerable energy savings over the life of a project. The GWP payback is a measure of the time in which the environmental impact of a product is paid back through a benefit offered, in this case energy savings. **Figure 4** shows the GWP payback periods associated with using ccSPF with Solstice LBA in the residential and commercial roofing applications evaluated. This shows that within as few as six months, ccSPF with Solstice LBA starts providing a net environmental benefit for the remainder of the project service life.

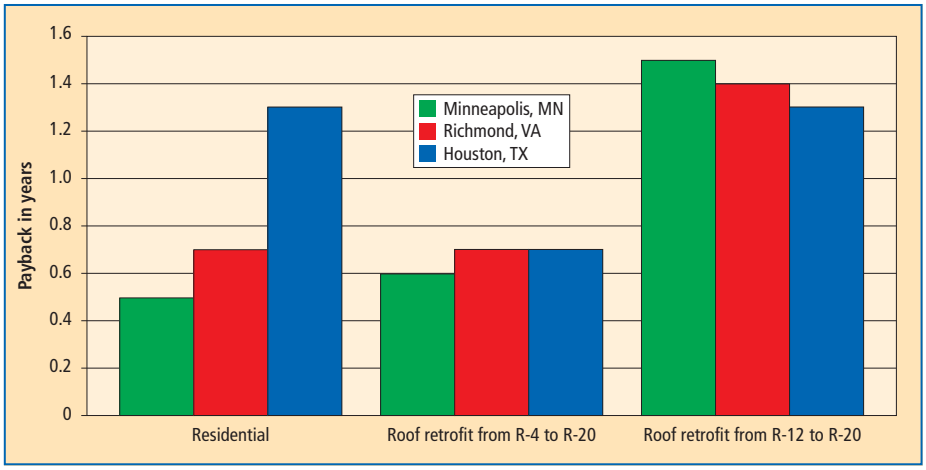
5. Summary

LCAs will likely gain an increasing role as one of many product selection criteria. In fact, certain countries in Europe have already embarked on carbon labeling requirements and test programs allowing consumers to better understand the possible relative impact of individual product selections. As standards and evaluation techniques are refined, product comparison rules will need development in order to provide a direct, reliable and meaningful comparison. For ccSPF, as an alternative to a simple product LCA, the environmental payback evaluation can be an effective tool to assess the product's true environmental impact since ccSPF provides significant energy savings over its service life.

▼ ***Fig. 3:*** *Relative environmental impact of common construction products*



▼ ***Fig. 4:*** *ccSPF with Solstice LBA – GWP payback period*



The LCA for Solstice LBA was conducted to fully evaluate the environmental impact of using this advanced blowing agent technology in ccSPF insulation applications. The analysis reveals that Solstice LBA is an attractive blowing agent for meeting the stringent design criteria of evolving green criteria and US buildings codes such as LEED, IgCC and Title 24. Of growing interest, and in particular the green design community, are the discrete environmental impacts of a product specified as well as the overall environmental payback associated with a product use. The Solstice LBA study revealed that the use of this innovative blowing agent technology results in very attractive product environmental benefits when used in current ccSPF formulations. In addition to attractive product environmental properties, the energy savings associated with the product use was demonstrated to fully offset any product environmental impact within as few as six months of service life. With a GWP < 5 and approval for use in foam applications under EPA SNAP, Solstice LBA offers a commercially ready, environmentally friendly alternative for maintaining the requirements of high performance insulation materials such as ccSPF while meeting the stringent requirements of design and consumer groups globally.

(Solstice LBA is a trade name belonging to Honeywell Inc.) ■

PU chemicals and products in Europe, Middle East & Africa (EMEA), 2012

IAL Consultants has published the ninth edition of its report on the markets for polyurethane chemicals and products in Europe, Middle East and Africa. This new study updates and expands upon the information included in the previous study published in 2010. The information contained within the report is based upon a programme of interviews throughout the industry. The report contains both PU product production and raw material consumption figures with 2011 as the base year and market forecasts provided to 2016.

According to the study, the polyurethanes industry has recovered to a great extent from the impact of the global recession. Total production of polyurethane products is reported to have been 5,449,400 t in 2011 compared with almost 5.1 million t in 2009 and 5.4 million t in 2007. By 2016 this figure is forecast to be 6,351,125 t, equivalent to an average growth of 3.1 % annually over the next five years, despite continuing concerns surrounding the global economy. Of the three regions considered, the polyurethane industry remains the largest in Western Europe, but growth rates are strongest in Eastern Europe and the Middle East/Africa region.

According to IAL Consultants, MDI and TDI are essentially marketed as commodity aromatic chemicals, with EMEA consumption of approximately 1.53 million t and 617,000 t respectively in 2011. Demand for TDI rebounded significantly in 2010 after the economic crisis, particularly from the furniture, bedding and automotive sectors.

Future growth is likely to follow GDP growth rates in Western Europe, but to be slightly higher in Eastern Europe and the Middle East/Africa. Demand in 2011 was quite flat, whereas consumption of MDI grew by around 2 % in the same year.

▼ *Total EMEA production of all PU products and annual growth rates by region*

Country	2011	2016 (forecast)	2011 – 2016 (% growth per year)
Western Europe	3,314,300 t	3,653,095 t	2.0
Eastern Europe	919,820 t	1,157,580 t	4.7
Middle East and Africa	1,215,280 t	1,540,450 t	4.9
Total EMEA	**5,449,400 t**	**6,351,125 t**	**3.1**

(Source: IAL Consultants)

Several new raw material facilities are currently under construction, including BASF's 300,000 t/y TDI plant at Ludwigshafen, and Bayer's new TDI and MDI facilities at Dormagen and Brunsbüttel respectively (300,000 t/y TDI, 220,000 t/y MDI). To serve the ever-expanding Middle Eastern markets, Dow and Saudi Aramco have established a joint venture to produce MDI, TDI, propylene oxide and polyols.

This is expected to be up and running in Jubail Industrial City, Saudi Arabia, in 2016. It is likely that new polyol capacity will be required in EMEA over the forecast period in line with the world-scale isocyanate plants being built in the region, says IAL.

Other parts of the report are dedicated to foam and non-foam products and major end-use markets.

+ online

The report is available for the following prices:

Volume 1 – Raw Materials: EUR 5,000;
Volume 2 – Foam Products: EUR 6,000;
Volume 3 – Non-foam Products: EUR 4,000;
Volume 4 – Major End-Use Markets: EUR 4,000;
Volume 5 – Executive Summary (only available to purchasers of the complete study);
complete report: EUR 14,500.

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