The Ecological and Economic Benefits of UV-Curing Technology

By Charlene A. Wall, Bradley M. Richards and Christopher Bradlee

The repair and refinishing of an automobile, returning it to showroom appearance, requires the hands-on expertise of a craftsman. Over the last few decades, these craftsmen have become more sophisticated in order to meet consumer quality demands while, at the same time, more sensitive to environmental concerns. These craftsmen are now turning to an exciting technology that promises to take the refinish process to the next level.

UV-cured coatings promise enhanced performance, higher productivity and an improved environmental footprint vs. traditional thermally cured coatings.

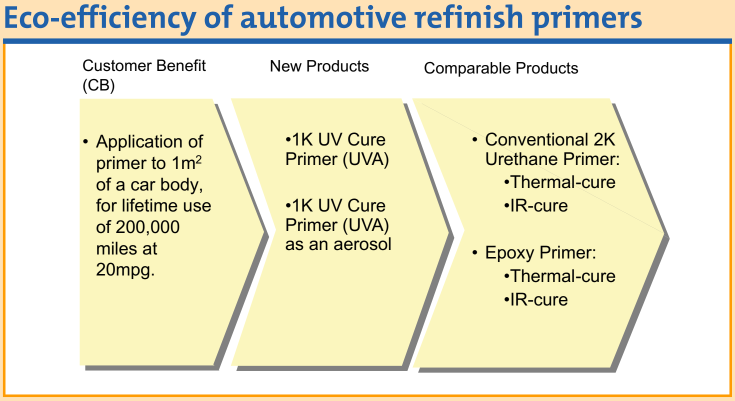
In the past two years, a few coatings companies have introduced a new, yet proven, technology to refinishers—UV-cured undercoats. Refinish painters are embracing this technology, finding significant advantages over conventional systems.

Eco-efficiency is a methodology that assesses the environmental and economic impacts of products and processes over their life-cycle.[1] Since its inception in 1996, more than 220 analyses have been completed on products ranging from vitamins to basic chemicals. The methodology is based upon the ISO14040 standards for life-cycle analysis and contains some additional enhancements that allow for expedient review and decision-making at all business levels.[2]

UV-cured coatings promise enhanced performance, higher productivity and an improved environmental footprint vs. traditional thermally cured coatings. Eco-efficiency is one tool that can be used to strategically develop and pursue the best products. Thus, it's a natural fit that eco-efficiency quantifies and demonstrates the benefits of UV technology. In the future, eco-efficiency will be used to further optimize coatings and other technologies.

FIGURE 1

Eco-efficiency of automotive refinish primers



Analyzing the Eco-efficiency of Automotive Refinish Primers

The first step is to define the customer benefit (CB), so that the application and use for all of the alternatives considered can be compared. Here, application and

TABLE 1

Coating data

		1K UV-Cure	2K Urethane	Epoxy	1K UV-Cure Aerosol
Transfer effciency	%	65%	65%	65%	75%
Film Thickness	mil	3	3	3	3
Total Solids	wt %	80%	56%	58%	43%
Specific gravity	lb/gal	12.3	11.0	10.7	5.9
Coverage at 1 mil	mils*ft2/gal	1022	548	616	354
VOC	lbs/gal	1.7	4.7	4.4	4.5
Pot life	hrs @ 20C/68F	no limit	0.5	24.0	no limit
Additional material mixed[a]	%	5%	10%	10%	5%

[a] This factor covers excess material which must be prepared to address issues such as limited pot life.

curing of primer on one square meter of automobile surface area is considered. The six primer technologies compared are described in Figure 1. The study encompasses production, application and curing of the coatings, cleaning of application equipment between applications, and fuel consumption of the automobile over its lifetime, resulting from the weight of coating on the vehicle.

Coating application and curing parameters are based upon manufacturers' recommendations. Key data are shown in Table 1.

The most significant differences in the coatings are in their application. As can be seen in Table 2, preparation time is shorter for the UV-cured coatings because they do not necessitate combining two separate components prior to mixing. In addition, the UV-curing times are significantly shorter than the thermal curing times. Finally, cleaning of spray equipment is either non-existent, for the UV-cured primer in aerosol cans, or drastically less than for the urethane and epoxy coatings. This is due to the longer life of the UV-cured primer, which means primer can be left in the spray gun between applications without the concern of solidification.

In order to assess the economic portion of eco-efficiency, the costs of using each of the products are considered. Table 3 depicts the costs for a bodyshop that currently processes five one-square meter jobs per day. Because of the efficiencies of the UV-cured coatings in coating preparation, application, equipment cleaning and cure times, a bodyshop is able to process individual jobs more quickly and consequently increase their

TABLE 2

Application data

	1K UV-Cure	2K Urethane-thermal	Epoxy-thermal	2K Urethane-IR	Epoxy-IR	1K UV-Cure Aerosol
Mixing of components	no	yes	yes	yes	yes	no
Coats	1	2	2	2	2	2
Flash-time between coats, minutes	0	10	10	10	10	1
Flash-time before lamp-cure, minutes	5	n/a	n/a	n/a	n/a	5
Curing Time, minutes	3	25	20	13	13	3
Spray equipment cleaning frequency	1/day	1/job	1/job	1/job	1/job	n/a

Table 3

Cost for application and use of automotive refinish primers

Cost Category	UNITS	Technology: 1K UV-Cure	2K Urethane-Thermal	Epoxy-Thermal	2K Urethane-IR	Epoxy-IR	1K UV-Cure-Aerosol
Materials	**$/job**	**$ 15.29**	**$ 7.47**	**$ 6.64**	**$ 7.47**	**$ 6.64**	**$ 52.14**
Labor Cost per Job	*$/job*	*$ 9.66*	*$ 13.62*	*$ 13.62*	*$ 12.03*	*$ 12.03*	*$ 11.56*
Energy Cost per Job	$/job	*0.024*	*3.693*	*2.110*	*0.065*	*0.049*	*0.024*
Total Cleanup Cost per Job	*$/job*	*$ 0.346*	*$ 2.185*	*$ 2.119*	*$ 2.185*	*$ 2.119*	*$ -*
Rework Costs	$/job	$ -	$ 6.74	$ 6.12	$ 2.72	$ 2.61	$ -
Total Cost Per Customer Benefit	**$/job**	**$ 25.32**	**$ 33.71**	**$ 30.61**	**$ 24.48**	**$ 23.45**	**$ 63.72**
Total Annual Revenue Increase							
Total Time per Job	min/job	36	84	69	57	57	42
Base number of Jobs/Year	Jobs/yr	1,250	1,250	1,250	1,250	1,250	1,250
Capacity Increase	jobs/yr	500	-	-	-	-	500
Revenue per Job	$/job	$ 200	$ 200	$ 200	$ 200	$ 200	$ 200
Total Annual Revenue	**$/yr**	**$ 350,000**	**$ 250,000**	**$ 250,000**	**$ 250,000**	**$ 250,000**	**$ 350,000**
Total Annual Revenue Increase	**$/yr**	**$ 100,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 100,000**

productivity. Increased productivity leads to higher profitability. A University of Michigan study[3] found a 40% capacity increase based on cycle-time decreases from 14 hours to 9 hours for a shop handling five vehicles per day using UV-cured coatings. Assuming a base number of 1,250 jobs per year, this means that 500 additional jobs could be processed. The resultant potential revenue increase from using the UV-cured coatings is $100,000 per year.

Eco-efficiency Results

Figure 2 shows the relative impact of the primers in six environmental categories. The most significant differences occur in emissions, energy and resource consumption, land use and risk potential. The overall health effect potential for the primers is similar.

The greatest environmental benefit of UV-cured coatings is the outstanding efficiency of the curing process. Figure 3 shows the individual energy consumption data, which are summarized on the ecological fingerprint.

The thermally cured coatings have longer, more energy-intensive curing

Figure 2

Ecological fingerprint for automotive refinish primers

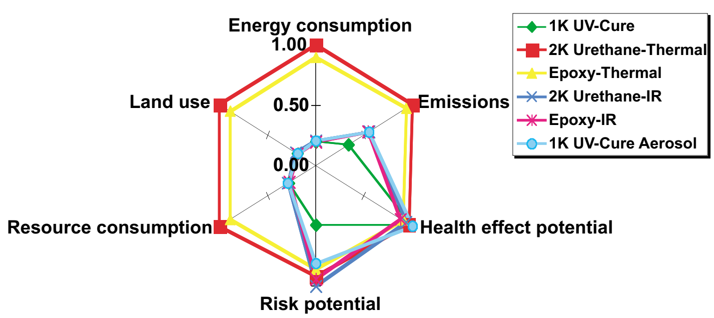
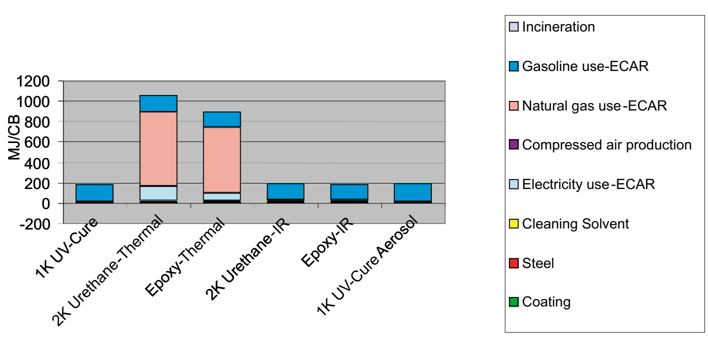


Figure 3

Energy consumption



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processes, which consume large quantities of natural gas and result in correspondingly higher environmental impact and utility cost. This characteristic is also the reason for the high resource consumption of the thermally cured coatings.

The overall emissions results are primarily impacted by the air emissions. Figure 4 shows the global warming (GWP) and photochemical oxidant (i.e. smog) creation potentials (POCP) for the alternatives. The thermally cured coatings have the highest GWP due to the natural gas produced and used for curing. The UV-cured primer in cans has the lowest smog creation potential (POCP) because it has the lowest VOC content.

Figure 5 shows the costs per customer benefit for each of the coatings. The labor and material costs are the most significant. The efficiencies in preparation, application and curing of the UV-cured coating in cans results in similar total costs to the urethane and epoxy coatings. In addition, with the urethane and epoxy coatings, there is potential for die-back, which results in re-work and additional cost. Although the material cost of the UV-cured coating in aerosol cans is high, its advantage is convenience.

As shown in Table 3, an annual revenue increase of $100,000 is possible if a bodyshop switches to UV-cured coatings. If, however, the shop continues to use the urethane or epoxy coatings, and the lost revenue per job is combined with the costs depicted in Figure 5, the resulting total cost of ownership is shown in Figure 6. It can clearly be seen that the UV-cured coating in cans has a much lower total cost of ownership.

Conclusions

The eco-efficiency portfolio consolidates all of the individual environmental and economic results into one representation, allowing for an overall picture of which products are best. The most eco-efficient products lie in the upper right-hand quadrant, which corresponds to the lowest environmental and cost impacts. Figure 7 shows the portfolio for automotive refinish primers when the total cost of using the products is considered. The UV- and IR-cured primers in cans are the most eco-efficient—due to the more efficient

FIGURE 4

Air emissions

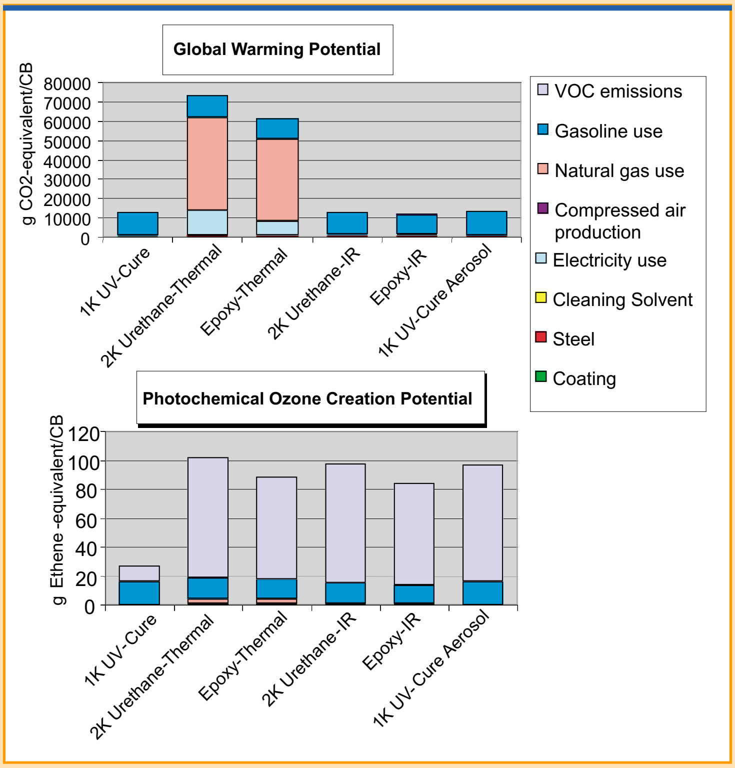


FIGURE 5

Costs

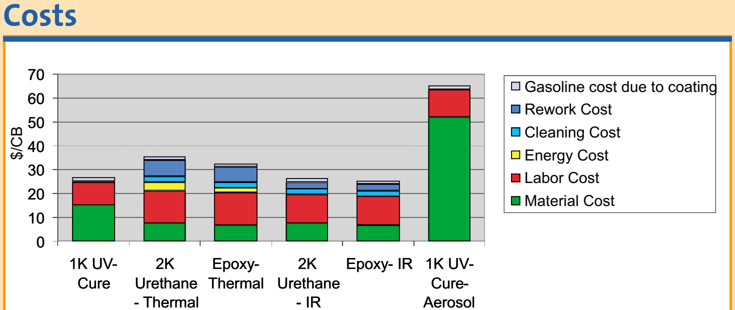


FIGURE 6

Costs + revenue loss

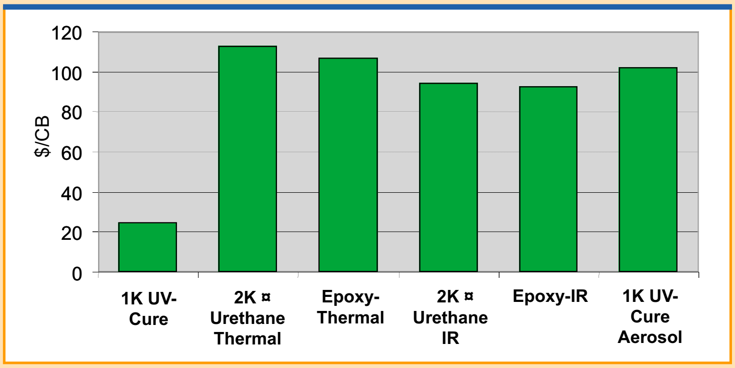


FIGURE 7

Eco-efficiency portfolio

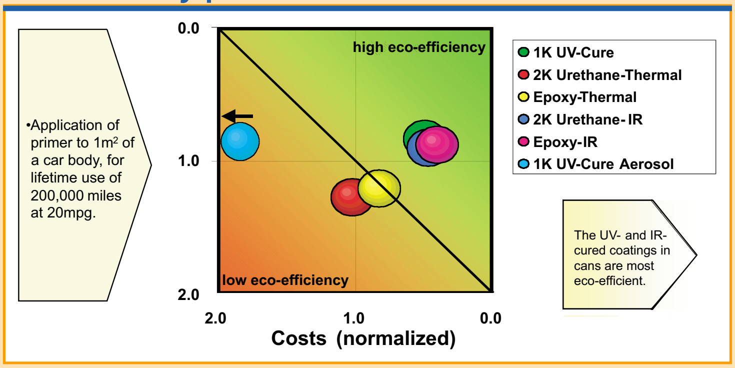
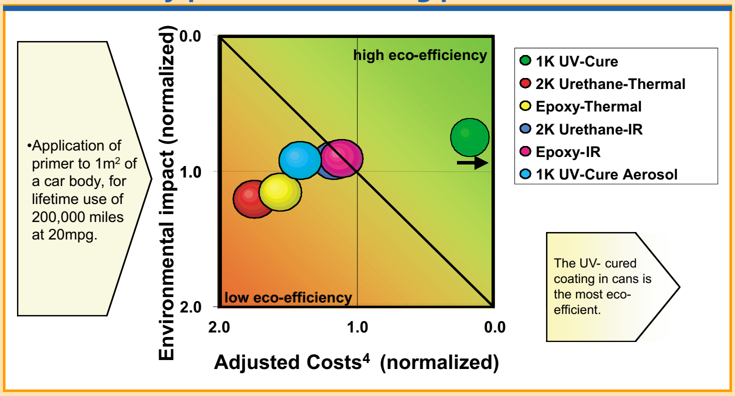


FIGURE 8

Eco-efficiency portfolio including potencial lost revenue



curing processes they have less overall environmental impact and lower costs than the thermally cured coatings. The UV-cured coating in aerosol cans has similar environmental impact to the non-aerosol product; however, the higher material cost results in lower eco-efficiency.

When the potential revenue increase for switching to the UV-cured coatings is considered, their eco-efficiency improves significantly. Figure 8 shows that the UV-cured coating in cans truly differentiates itself from the other products, while the aerosol becomes much more comparable to the IR- and thermally-cured products.

The key to a successful product is both environmental and economic advantage over competing products. UV-cured primers provide both of these and are successful products that support industry sustainability initiatives.

References

1. Saling, P.; Kicherer, A.; Dittrich-Kraemer, B.; Wittlinger, R.; Zombik, W.; Schmidt, I.; Schrott, W.; Schmidt, S. Int. J. Life Cycle Assess. 2002, 7 (4), 203.
2. The methodology was created in partnership with an external consultant, and has been further developed by BASF. BASF's eco-efficiency group has conducted over 220 analyses.
3. University of Michigan Business School, MAP Team 1, April 2002.
4. Costs adjusted for increased revenue potential due to cycle time reduction.

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