Multilateral Fund
for the Implementation of the Montreal Protocol

OBJECTIVE

To strengthen the capacity of two local systems houses to formulate, test, and produce pre-blended polyols using HFOs for small and medium sized enterprises (SMEs) in the PU spray foam sector. To validate and optimize the use of HFOs co-blown with CO_2 for spray foam applications to achieve a similar thermal performance to that of HCFC-141b with minimum incremental operating costs.

DEMONSTRATION OF PRE-BLENDED POLYOLS USING LOW-GWP BLOWING AGENT FOR SPRAY POLYURETHANE (PU) FOAM

Project title	Demonstration project at foam systems houses to formulate pre-blended polyols for spray polyurethane (PU) foam applications using a low-GWP blowing agent
Country	Thailand
Agency	World Bank
Sector	Foam
Subsector/application	Rigid PU foam: spray foam
Enterprise/ systems house	Bangkok Integrated Trading Co. Ltd (BIT), and South City Polychem Co., Ltd (SCP)
Baseline technology	HCFC-141b
Alternative technology	HFO-1233zd(E), HFO-1336mzz(Z), HFO/CO_2
GWP (alternative technology)	Negligible
Potential safety issues	HFO-1233zd(E) and HFO-1336mzz(Z): non-flammable
ODS phase-out (mt)	35.30
ODS phase-out (ODP tonnes)	3.88

DESCRIPTION

The project was implemented at two systems houses, BIT and SCP, which formulated high density spray foam (50 kg/m^3) and normal density spray foam (35 kg/m^3). Each systems house prepared and tested a minimum of 110 formulations based on HFO-1233zd(E) and HFO-1336mzz(Z); five HFO/CO_2 ratios (i.e., 100:0, 75:25, 50:50, 25:75, and 0:100); and five cycles based on different ratios of polyether, polyester and amine polyols. The resulting formulations were applied using a new spray foam machine (Graco) with a maximum pressure of 3,500 psi and adjustable polyol to isocyanate ratio. The results were analysed to identify the best combinations of polyols. The top 30 foam formulations were tested (three samples from each formulation), and the critical foam properties (i.e., dimensional stability, adhesion to different substrates, thermal conductivity, and processability) were compared to those of a typical HCFC-141b formulation. A field test with selected formulations was carried out. A technical workshop was organized to disseminate the results. Access to experts and technology suppliers was given to the systems houses and polyol suppliers to transfer knowledge and strengthen their technical capacity to develop formulations.

RESULTS

Both systems houses found that percentages of HFO equal to or above 10% exhibited acceptable characteristics; while the formulations with 5% of HFO either provided poor performance with regard to adhesion and shrinkage, or their higher water content affected the foam stability, which could result in higher K-factor or friability of the final foam product.
Accordingly, the test results of the key performance parameters for BIT and SCP are based on formulations with 10% blowing agent or above, as shown in Table 1.

Several of the tests (K-factor, compressive strength, dimensional stability) were also undertaken several weeks later for comparison with the initial values. Detailed information on field tests and performance at BIT and SCP are available in the report on the demonstration project, linked under the "Final report" section.

Table 1. Test results of key performance parameters for BIT and SCP.

Parameter	BIT			SCP		
	HCFC-141b	1233zd(E)	1336mzz(Z)	HCFC-141b	1233zd(E)	1336mzz(Z)
Percentage of blowing agent	30%	13%	10%	30%	10%	10%
Reactivity						
Cream time (sec)	4	4	5	3	4	4
Gel time (sec)		9	9	5	6	6
Tack-free time (sec)	16	16	16	8	7	7
Foam properties						
Foam density (kg/m3)	38.04	38.77	39.07	38.18	39.51	34.64
K-Factor (mW/mK)	21.40	24.20	26.10	20.00	24.74	26.88
Compressive strength (kPa)	184.80	188.20	190.59	194.00	256.00	206.00
Dimension stability 70ºC (%ΔV) (after 1 week)	0.40	0.68	0.58	1.96	0.43	-0.56
Dimension stability -30ºC (%ΔV) (after 1 week)	-0.87	-0.77	-0.83	-0.34	-0.46	-0.48

COST ANALYSIS

To ensure fast-track adoption, the costs of new HFO formulations must be competitive compared to HCFC-141b formulations. Table 2 provides a cost comparison between the HCFC-141b formulations and the two HFO formulations. HFO-based blowing agent percentage in the systems was 4.7% compared to 10% of HCFC-141b.

Table 2. Cost comparison between the HCFC-141b formulations and the two HFO formulations.

Cost parameters	BIT		SCP	
	1233zd(E)	1336mzz(Z)	1233zd(E)	1336mzz(Z)
Cost of PU system (US $/kg)	2.61	2.96	2.74	2.82
Incremental operating cost (US $/kg HCFC-141b)	4.72	8.24	8.10	8.88

The cost of new spray foam machine procured at BIT and SCP was US $43,700 and US $41,700 respectively, and the cost of the thermal conductivity tester was US $29,800 and US $22,250 respectively. Equipment prices can vary based on commercial factors.

CONCLUSION

The results confirmed that:

- Spray foam formulations with HFO blowing agents of about 10% of the polyol weight and proper choice of polyol and catalyst package could yield foam properties that were comparable to HCFC-141b formulations.
- The introduction of a new catalyst package resolved issues of instability in the HFO-1233zd(E) formulation.
- Spray foams blown with HFOs exhibited adhesion performance that was acceptable to the market.
- The reactivity time of the new reduced-HFO formulations is similar to the HCFC-141b formulation.
- Density of spray foam made from the reduced-HFO formulations was slightly higher than the baseline HCFC-141b formulation.
- A slight increase in compressive strength was also observed. Similarly, the initial K-factors of the reduced HFO formulations were 20 – 30% higher than the HCFC-141b formulation.
- All properties of HFO-blown foams were maintained stable over time.
- Both HFO formulations passed the fire performance tests.

Reduction of the blowing agents required an additional amount of water to generate CO_2 from the water-isocyanate reaction. Consequently, an additional amount of isocyanate was required, which made the polyol and isocyanate ratio by volume deviate from 1:1. Spray foam enterprises may need to either retrofit or replace their existing spray machine to be able to apply these new formulations with a polyol-isocyanate ratio different from 1:1.

FINAL REPORT AND SECRETARIAT'S COMMENTS

Additional details on this project are available at the link below:

http://www.multilateralfund.org/83/English/1/8311.pdf
(paragraphs 247 to 259 and Annex V)