VATIS Update Ozone Layer Protection . Jan-Feb 2005

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THE SCIENCE OF OZONE LAYER

Ozone hole below long-term normal

The 2004 Antarctic ozone hole season is now over, with the circulation over the continent in its summer mode. The ozone layer over much of the Southern Hemisphere south of 50 remains around 10 per cent below the long-term normal. The ozone hole (where ozone values are below 200 DU) grew rapidly from mid-August to early September to reach around 19 million square kilometres. It slowly decreased in area from a maximum of 20 million square kilometres in mid-September to 15 million square kilometres in early October. A major spring warming commenced in mid-October, when the area decline rather more rapidly to 6 million square kilometres. However, the warming subsided and the area affected slowly declined from around 10 million square kilometres in late October to around 8 million square kilometres in mid-November. The ozone hole area rapidly dropped to zero after mid-November. The area of the hole was generally a little below the average size recorded in the last decade.

In the Northern Hemisphere there is currently significant ozone depletion over the Arctic Ocean. Temperatures in the Arctic stratosphere are cold enough for stratospheric clouds to form and significant parts of the Northern Hemisphere have ozone levels more than 10 per cent below the normal.

Website: www.antarctica.ac.uk

New light on ozone hole

Scientists at NASA in the United States have announced that the agencys Aura spacecraft is providing the first direct, daily global measurements of low levels of ozone and those of many other pollutants that affect air quality. Measurements by Aura offer new insights into how climate changes influence the recovery of the Earths protective stratospheric ozone layer. According to Mr. Mark Schoeberl, Aura Project Scientists at NASA Goddard Space Flight Centre in Maryland, measurements like these will help us better understand how the ozone hole will react to future stratospheric cooling, which is expected as carbon dioxide levels continue to rise.

The presence of stratospheric ozone sandwiched between the satellite and the troposphere makes seeing tropospheric ozone very difficult. Auras Troposheric Emission Spectrometer uses new technology to see through the stratospheric ozone layer, to measure tropospheric ozone. Aura also provides new insights into the physical and chemical processes that influence the health of stratospheric ozone layer and climate. It is producing the most complete set of chemical measurements including chemically reactive hydrogen-containing species, as well as key forms of chlorine and bromine, which are involved in ozone destruction ever available to understand the ozone layer and its recovery.

Website: www.physorg.com

Ozone hole casts a southern shadow

The worst of the ozone hole has pulled back once more to Antarctica this southern spring, leaving behind a shadow of uncertainty for the people living at the bottom of South America. The people of wind-blown Punta Arenas, Chile, are adjusting to the intense radiation that pours in each year through the gap in the ozone layer. However, many of the 150,000 Punta Arenans take few precautions against a damaging sun, as they go about their business, said the local health chief Dr. Lidia Amarales. The reason is that it is cool in Punta Arenas. When it is 30C somewhere, people dont go out into the sun. Here, with 13C, they go outside, explained Dr. Amarales.

Air currents and intense cold in the polar region, combined with chlorine from CFCs, created a vast expanse of ozone-thin atmosphere that briefly reaches the tip of South America each southern spring. Ozone here was found in October 1992 to have thinned to 147 DU, less than half the normal 333 DU. Consequently, ultraviolet radiation has multiplied many times, in its most damaging wavelengths.

As a result of worldwide action following the signing of the Montreal Protocol, depletion of ozone layer has slowed down. This Septembers maximum ozone hole, at about 11 million square miles, was markedly smaller for the second straight year from the huge 17 million square mile hole of 2002. Mr. Claudio Casiccia, at the Ozone Laboratory of the University of Magallanes, is non-committal. He said that the trend would need to continue for several years before one could take it as a sign of ozone recovery. Mr. Casiccia and others worry about unforeseen new compounds damaging the ozone shield and about the exemptions granted from the Montreal Protocol.

Website: www.cnn.com/worldnews

HFC emissions are at low level

The global increase of fluorinated gases (F-gases) emissions 98 per cent compared with a low baseline set in 1995 is the consequence of continuing replacement of ODS under the Montreal Protocol. However, putting this in perspective, CFC emissions represented in 1990 around 25 per cent of total greenhouse gases emissions, while HFC emissions presently account only for 1 per cent. Despite the continuing replacement of ODS and the increase of air-conditioning in Europe, the total HFC emissions in the European Union will remain small, according to report of the European Fluorocarbon Technical Committee (EFCTC).

Furthermore, since the impact of an amount of HFC emitted is much less than the impact of the same amount of CFC emission, CFC substitution with HFCs is beneficial for the climate and brings a significant improvement in the climatic impact of their uses. The EFCTCs claim that the HFC emissions would remain under 2 per cent by 2010 is substantiated by country-wise projections presented in the report. It must be noted that CFCs, covered under the Montreal Protocol, are not included among F-gases in the Kyoto Protocol, which registers only HFCs, PFCs and sulphur hexafluoride as F-gases.

Website: www.fluorocarbons.org

ODS PHASE-OUT IN INDIA

UNDPs support for ODS phase-out activities

In 1993, the Ozone Cell at the Ministry of Environment and Forests (MoEF), as the lead national agency for ODS phase-out, prepared the Country Programme for India with the assistance of the United Nations Development Programme (UNDP). It constituted six industry groups representing aerosols, foam, refrigeration and air-conditioning, halon, solvents and chemical producer sectors. UNDP has been assigned the responsibility of consumption sectors for foam, halon, aerosols and commercial refrigeration. It has implemented a number of projects under the foam, halon and aerosol sectors, deriving technical assistance from national and international consultants with the assistance of the United Nations Office for Project Services (UNOPS). To date, UNDP has mobilized US$32 million from the Executive Committee of the Multilateral Fund to help the Indian industries including several small and medium enterprises in their endeavour to phase out ODS.

Recently, UNDP received assistance from the Multilateral Fund for the Phase-Out Plans for Foam and Refrigeration Manufacturing Sectors, which are being directly implemented by UNDP under DEX modality, with UNOPS assistance for the personnel component. The future strategy of UNDP is to work for the carbon tetrachloride (CTC) and servicing sectors. UNDP has received resources worth US$5 million from Japan for the CTC sector, and will receive US$1.5 million from the Multilateral Fund for the servicing sector. Preliminary work related to issuance of Expression of Interest and Invitation to Bid has commenced.

Website: www.undp.org.in

ITPI launches CFC phase-out action

IT Power India (ITPI) Pvt. Ltd., has launched its activities under the National CFC Consumption Phase-out Plan or NCCoPP, an environmental project to preserve ozone layer. The plan aims to achieve a complete phase-out of CFC-based refrigeration in India by 2010, by eliminating the technologies that use ozone-depleting chemicals such as CFCs. NCCoPP is financially supported by the Multilateral Fund of the Montreal Protocol through bilateral assistance from the governments of Germany and Switzerland. It is implemented by the Ozone Cell of the Ministry of Environment and Forests along with four other agencies.

Speaking on the occasion, Mr. Ashok Matta, head of the Chandigarh Training Cell of ITPI, said training would be a core component of ITPI activities under NCCoPP. The plan will deal with matters like good practices in handling CFC, servicing and retrofitting of appliances using alternatives like HFC and hydrocarbon refrigerants, and how to recover and reuse CFC and HFC refrigerants. Another activity under NCCoPP would be to provide service equipment to refrigeration service enterprises based on CFC consumption. The equipment will include tools to evacuate CFC gas and recharge the refrigerator, as well as special equipment to recover CFC gas and store it safely.

Under NCCoPP, ITPI has been appointed as: a Regional Management Organization for managing training partners in southern and western parts of India; National Service Provider for managing other activities in India related to training; and Facilitator for Equipment Support Scheme for refrigeration small enterprises.

Contact: IT Power India Pvt. Ltd., No. 6, Romain Rolland Street, Pondicherry 605 001, India. Tel: +91 (413) 222 7811, 234 2488; Fax: +91 (413) 234 0723, 233 2776

E-mail: itpi@itpi.co.in

Website: www.cities.expressindia.com

www.itpi.co.in

Training under NCCoPP

Since 2001, the Appliance Division of Godrej & Boyce Mfg. Co. Ltd. has been working as an industry member of the Human Institutional Development in Ecological Refrigeration (HIDECOR), which ends in December 2004. It continues to work for ODS phase-out under the National CFC Consumption Phase-out Plan (NCCoPP) and will support the technicians of refrigeration and air-conditioning (RAC) service sector all through the changeover to new/alternative technologies. Till December 2003, it had trained 1,200 maintenance and service engineering (MSE) technicians under HIDECOR and plans to train another 300 before the project winds up. This is in addition to the 1,200 technicians engaged for its own appliances trained till December 2002.

Training a critical group of service technicians in the new RAC technologies is one of the main goals of NCCoPP, which will commence from October-November 2004 and will be operational for five years. Godrej is engaged in the project as a National Training Partner for Training of Trainers and Technicians in the refrigeration service sector throughout India, as well as a Technical/Industry Consultant for India. Other responsibilities will be towards updating the training material, NCCoPP equipment supply, monitoring of training programmes conducted by various training partners, etc.

Contact: Mr. S.A. Juvekar, Appliance Division, Godrej & Boyce Mfg. Co. Ltd.

E-mail: saj@godrej.com

Website: www.godrejsmartcare.com

Textile industry to phase out ODS

The Textile Committee of India recently organized a workshop aimed at sensitizing the textile industry over the use of ozone depleting stain removing chemicals in their manufacturing units and inviting suggestions for alternatives. Carbon tetrachloride, one of the chief ozone depleting chemicals, is widely used as a degreasing and cleaning agent in the dry-cleaning and textile industries. According to the Montreal Protocol we have to phase out the use of these both, instant removers and cleaning agents employed in the textile manufacture, said Dr. G.S. Nadiger, Director (Laboratories), Textile Committee of India. "India is steadily moving towards phasing out ODS," said Mr. M. Wypior, the programme manager of GTZ, a German development agency, which is supporting India in controlling the level of ODS.

Website: www.newkerala.com

IN THE NEWS

The Prague Declaration

The ministers of the environment and heads of delegation of 62 nations and political unions who are Parties to the Montreal Protocol adopted a declaration on Enhancing Cooperation Among Chemical Related Multilateral Environmental Agreements on 26 November 2004 during the 16th Meeting of the Parties of the Montreal Protocol in Prague, the Czech Republic.

The declaration covered the following points:

1. Reaffirm their commitment to continue their efforts to protect the global environment and the ozone layer, bearing in mind in particular the Rio Principles, including the principle of common but differentiated responsibilities;
2. Stress the need in particular, to implement the relevant elements of the WSSD Plan of Implementation concerning the sound management of chemicals, including the prevention of international illegal trade of ozone-depleting substances, hazardous chemicals and hazardous wastes;
3. Emphasize the need for developing countries to implement multilateral environmental agreements and mainstream environmental considerations in their sustainable development and poverty reduction strategies to maximize the efficiency of the technical and financial support provided;
4. Reiterate the need to help provide support for the implementation of chemicals-related multilateral environmental agreements to developing countries and countries with economies in transition, for the Montreal Protocol including through an adequate replenishment of the Multilateral Fund for the Implementation of the Montreal Protocol and the Global Environment Facility and enhanced cooperation between these funds;
5. Enhance the collaborative efforts towards technological development, in particular those relating to the protection of the ozone layer and the mitigation of climate change, and transfer of technology to the countries that need it;
6. Seek alliance with other multilateral instruments like the Basel, Rotterdam and Stockholm conventions to contribute to an effective strategic approach to international chemicals management; and
7. Declare the willingness of the Parties assembled in this City of Bridges to contribute to building bridges between the relevant multilateral environmental agreements and to help them draw inspiration from the success of the Montreal Protocol while, in turn, drawing inspiration from them in meeting future challenges.

Contact: Mr. Marco Gonzalez, Executive Secretary, Ozone Secretariat, United Nations Environment Programme, P.O. Box 30552, Nairobi, Kenya. Tel: +254 (2) 623 855; Fax: +254 (2) 623 913

E-mail: marco.gonzalez@unep.org

Website: www.uneptie.org/ozonaction

Bangladesh moves to control CFC trade

The Government of Bangladesh has undertaken a move to control import and use of CFCs and related substances. The Ministry of Environment and Forest has recently requested the Ministry of Commerce to incorporate CFCs in the Import and Export Policy 2003-06 as conditional import product. The Commerce Ministry is to soon hold a meeting to discuss the request. As one of the signatories of the Montreal Protocol, Bangladesh has started phasing out CFCs and methyl chloroform and introduced the Ozone Layer Depleting Substances Control Regulation 2004. Sources at the Department of Environment said that the government has

decided to control import and use of 96 types of gases, which are now widely imported, to avoid depletion of ozone layer.

Website: www.bangladesh-web.com

China and Venezuela to stop production of CFCs

China and Venezuela will stop producing CFCs and certain other ozone-depleting substances (ODS) from 2007, more than two years ahead of the date sipulated under the Montreal Protocol. Industrialized countries have already stopped the production of CFCs and similar greenhouse gases, while major developing countries such as India and Mexico have decided to halt their production. China, the largest producer of CFCs in the world, and Venezuela had been hitherto unclear about their intentions about halting the production of these substances.

The move to halt production of CFCs and other similar ODS comes after the decision to provide China with US$10 million and Venezuela with US$16.5 million from the Montreal Protocols Multilateral Fund. China will close its CFC and halon factories by July 2007 and Venezuela will shut down its CFC plants in January 2007. Experts agree that the Fund played a key role in helping phase out the production of CFCs and halon in developing countries.

Website: www.kyodo.co.jp

Philippines to monitor CFC trade

The Department of Environment and Natural Resources (DENR), through its Philippine Ozone Desk (POD), will strictly monitor illegal trade on ODS, as part of the countrys commitment to reduce ODS under the Montreal Protocol. Funded by the Multilateral Fund, POD will process pre-shipment importation clearances for CFCs and, in coordination with the Bureau of Customs, apprehend illegal CFC trade. Under the Protocol, the country is expected to eliminate CFC consumption by 50 per cent in 2005 and 85 per cent in 2007, and effect total phase-out by 2010.

The first phase of the US$30 million project calls for the elimination of CFCs in large enterprises under the foam, solvent, tobacco expansion and refrigeration sectors. The total phase-out by 2010 will cover remaining ODS in small and medium-sized enterprises. The project will also: introduce new technologies to replace old technologies that cause ozone depletion; involve more government agencies in carrying out CFC elimination; and implement cost-effective priority investment to reduce ODS consumption.

Website: www.dti.gov.ph

Nepal regains ozone-friendly status

Nepal is one of the 188 countries that have signed and ratified the Montreal Protocol to phase out chemicals that harm the Earths ozone layer. However, in 2001, when customs officials at Birganj seized an illegal shipment of 74 tonnes of India-bound CFCs, the country got blacklisted as a conduit for smuggled ozone-depleting substances. This besmirched Nepals international reputation and made it difficult for Nepali officials to convince the United Nations that it intends to adhere to its commitment to phase out ODS by 2010. It took about three years for Nepali delegations at international conferences to convince the Montreal Protocol secretariat that the impounded CFCs were smuggled into Nepal and the government had not issued import

licence for them.

The issue of what to do with the seized chemicals has also troubled Nepals position vis--vis the Montreal Protocol secretariat. Now, the Montreal Protocol secretariat has allowed Nepal to release the seized amount without exceeding the countrys permitted quota of 27 tonnes of CFCs per year. At a Montreal Protocol compliance conference in Prague in November, Nepal reiterated its commitment to phase out this annual consumption by 2010. Following the recommendations of an international consultant sent to Nepal for inspection, the secretariat has called for removal of any reference to non-compliance by Nepal. It also put on record that other countries could learn from Nepals transparency in declaring seized ODS and commended Nepal for its phase-out plan.

Website: www.nepaltimes.com

Viet Nam seeks support for its ODS phase-out

To achieve the 2010 target for eradicating use of specified ODS, the country will seek assistance from Multilateral Fund, according to an official of Viet Nams Ministry of Natural Resources and Environment. This move is part of a national plan for eradicating the consumption of some ODS, including CFCs and halon. The plan has recently been submitted to the government for approval.

Under the plan, the Ministry will provide free of cost sets of tools that can be used by businesses to repair refrigerating appliances as part of their after-sale service. The conditions are that these businesses commit themselves to not using ODS and send their workers for training courses held by the Ministry to learn new techniques for repairing refrigerating appliances. Currently around 1,000 workers are attending such training courses. According to the Ministry, Viet Nams previous average annual consumption was 500 tonnes of CFCs, which has now dropped to around 230 tonnes. The country has so far implemented 28 phase-out projects.

Website: english.vietnamnet.vn

REFRIGRATION/AIR-CONDITIONING

Performance-enhanced refrigerant alternative

Origin Energy, Australias leading energy supplier, has introduced 34m, a premium environmentally friendly air conditioning gas. 34m is a performance-enhanced R134a gas designed for medium temperature refrigeration and air-conditioning applications. It is an ideal replacement for the existing range of azeotropic and non-azeotropic refrigerants.

34m exhibits azeotropic characteristics operationally and offers the following benefits:

Sub-cooling at noticeably higher levels;

Significant improvements in sub-cooling drives increased system efficiency;

Accelerated temperature pull down; and

Reduced temperatures under full load.

Contact: Mr. Dominic Drenen, Environmental Refrigerants Manager, Origin Energy, Australia. Tel: +61 (3) 9652 5561

E-mail: enquiry@originenergy.com.au

Website: www.ferret.com.au

New range of refrigerant lubricants

CPI Engineering Services, South Africa, offers two different types of lubricants for use with highly fluorinated refrigerants such as R-134a (1,1,1,2 tetrafluoroethane). The RPAG Series fluids are made from a family of soluble polyglycol-based lubricants, which are inversely miscible with R-134a. The RPAG fluids have been designed mainly for automotive applications, but could also be employed in rotary screw compressors. They are not recommended for retrofit. The Solest Series products are formulated from modified ester base stocks to provide controlled miscibility, as well as solubility with all HFC-based refrigerants, including R-134a. They are mineral-compatible and can be used to retrofit existing CFC-based systems.

Hydrocarbon refrigerants are considered highly soluble in lower viscosity and reduced oil-film thickness. The washing away or absorption of lubricant into the gas phase in the compression cylinder may result in loss of lubrication. The CP-1516 Series selected polyglycols address these problems, as their lower solubility prevents dilution by hydrocarbons while their polar nature helps to preferentially wet lubricated surfaces.

Contact: Mr. Iain Johnstone, CPI Engineering Services, P.O. Box 26840, Houtbay 7872, Cape Town, South Africa. Tel: +27 (21) 790 8490; Fax: +27 (21) 790 8492.

Website: www.mbendi.co.za

Zero-ODP centrifugal chillers

York International Corporation a global supplier of heating and cooling equipment based in York, Pennsylvania, the United States has developed a full range of zero-ODP centrifugal chillers that employ HFC refrigerants. York has announced that it will not offer new chillers using HCFC-123 refrigerant, as the legislated phase-out of HCFC refrigerants has begun in 2004. York has been aggressively pursuing the development of zero-ODP chillers, and has succeeded in putting on the market a full portfolio of HFC-134a (R-134a) centrifugal chillers such as electric-drive chillers, gas-engine-drive chillers, and steam-turbine-drive chillers. It also has air and water-cooled screw chiller models that employ zero-ODP refrigerants.

Website: www.jarn.co.jp

Energy-efficient industrial water chillers

Ultracool chiller, developed and introduced by Donaldson Ultrafilter, is a new range of stand- alone, dedicated,

industrial water chillers that are cost-effective and energy efficient. Water for the process is taken into the heat exchanger where it is chilled by a separate refrigerant unit by use of environmentally friendly and non-ozone harming refrigerants. The refrigerant circuit ensures the pre-set temperature is achieved.

Ultracool chillers, which have relatively small footprint, come in two distinct styles related to capacity Mini and Midi. The Mini series covers 10 units with cooling performances between 1.86 kW and 33.55 kW (1,600 kcal/h to 28,850 kcal/h), with the capability of handling nominal water flow rates up to 5,770 litres/hour. It employs the environmentally friendly refrigerant R134a. Cooling performances above 40 kW are covered by the Midi series, which includes seven models for cooling performances from 40 kW to 170 kW (34,400 kcal/h to 146,200 kcal/h). Motors are protected by circuit breakers, high and low pressure security switches, and flow and level switches. For demanding operating conditions, the Ultracool range is available in a Superplus format, which features an internal by-pass system, water filtration up to 50 m and a stainless steel pump.

Website: www.ferret.com.au

Absorption chiller-heater

Yazaki Energy Systems Inc., Texas, the United States a leading supplier of non-CFC based cooling systems offers absorption chiller-heaters that use water as the refrigerant for protecting the environment and reducing the cost of energy. Double-effect cycles and advanced technology ensure high performance and long-term reliability. Capacities of 30 to 100 RT are available to cool or heat installations such as schools, offices, hospitals, hotels and industrial facilities.

Contact: Yazaki Energy Systems Inc., 13470 Omega Road, Dallas, Texas, TX 75244-4516, United States of America. Tel: +1 (972) 385 8725; Fax: +1 (972) 385 1324

E-mail: yazaki@yazakienergy.com

Website: www.escenter.org

Refrigeration oils for chlorine-free refrigerants

Synthetic ester-based refrigeration oils for new chlorine-free refrigerants such as R-134a, R-404a, R-407c, R-410a and R-507 are being offered by Fuchs Petrolub AG of Germany. The function of oil in a refrigerator compressor is to lubricate the pistons, the motor, the valves and sometimes the slipping seals. Most conventional lubricants can no longer be used with the new chlorine-free refrigerants and refrigerant mixtures because they are insoluble. Reniso E refrigerator oils from Fuchs Petrolub display excellent miscibility with chlorine-free refrigerants.

The main advantages of Reniso E refrigeration oils are:

Good solubility in HFC and FC refrigerants;

Very good thermal and chemical stability;

High natural viscosity index;

They are ultra-dried;

No oil build-up in the condenser/evaporator, which ensures reliable performance; and

Good compatibility with all materials commonly used in refrigeration systems.

Contact: Fuchs Petrolub AG, P.O. Box 10 11 62, D-68145 Mannheim, Germany. Tel: +49 (621) 3802-0; Fax: +49 (621) 3802-1 90

E-mail: contact-de.fpoc@fuchs-oil.de

Website: www.fuchs-oil.de

Replacement for R-12

AutoRefrigerants Inc. of Michigan, the United States, offers Freeze-12, a refrigerant alternative to R-12 (Freon) In air-conditioning systems. The performance and efficiency of Freeze-12 are very similar to that of R-12. The CFC-free Freeze-12 is non-flammable and is EPA-accepted. It is the ideal replacement for older R-12 systems because it works with existing R-12 lubricant. Mechanically, one may tap Freeze-12 cans with either its unique cantap or a universal side-tap. The latter would allow the use of standard R-12 gauges with the cans.

Contact: AutoRefrigerants Inc., 123 Lakeshore Drive, Lachine, Michigan, 49753, United States of America. Tel: +1 (989) 354 2836

E-mail: director@autorefrigerants.com

Website: www.autorefrigerants.com

Absorption chiller-heaters

Broad Air Conditioning Co. Ltd., China, is reported to be the largest absorption chiller company in the world and the only manufacturer to have all its chillers with CE mark, UL and ETL listing, and ASME certification. It specializes in the manufacture of absorption chillers/heaters, which employ a cooling cycle that uses naturally occurring fluids, water and lithium bromide, where water is the primary refrigerant and lithium bromide the absorbent. These chiller-heater systems are thermally activated to perform the absorption cycle using various kind of fuels such as natural gas, diesel, steam, hot water, or waste heat from generators and industrial systems. They are available with cooling capacities ranging from 16 kW to 23,260 kW (4.6 RT to 6,614 RT).

Contact: Broad Air Conditioning Co. Ltd., Borad Town, Changsha, Hunan, China. Tel: +86 (731) 408 6688; Fax: +86 (731) 461 1357

E-mail: international@broad.net

Website: www.broad.com.cn

SOLVENTS

Cleaners and degreasers

SMI Industrial Electronics of Canada offers cleaning and degreasing solvents under the brand MG Chemicals for use in the electronics industry. HFE Solvent 411 is a non-inflammable, non-conductive, solvent with fast dry time and very low toxicity. It could be used to clean energized circuits, contacts, motors and other electronic equipment. It is safe on plastics and leaves no residue. It is a TF solvent replacement, approved by SNAP without restrictions. The HFE Heavy Duty Cleaner Degreaser 412 has all the uses of HFE Solvent 411, but could also remove dirt, grime, grease, oil, oxides, silicones, flux and carbon. It has medium toxicity, is safe on some plastics, and is SNAP-approved replacement for 1,1,1 trichloroethane and HCFC solvent. These fully ozone-safe solvents are available in liquid and aerosol forms, in cans with variable valve that allows greater user control.

SMI also offers denatured Ethanol 4050, which is a special blend of ethyl alcohol, isopropanol and ethyl acetate. It is strong enough to clean grease, oil, smoke residue, ink, and both organic and inorganic dirt. It comes in , 1, 20 and 200 litre packs.

Contact: SMI Industrial Electronics, #109, 20120 64 Avenue, Langley, British Columbia, V2Y 1M8, Canada. Tel: +1 (604) 533 3967; Fax: +1 (604) 533 7056

E-mail: smi@smi-elec.com

Website: www.smi-elec.com

Cleaners for contacts and circuit boards

Amrep Inc. of Georgia, the United States, offers Misty brand of solvent cleaners for use in the electronics sector. The Misty Contact & Circuit Board Cleaner III is a fast-drying, non-conductive formulation that leaves no residue and is safe on plastics, rubber and metal. This ozone-safe spray product easily cleans oil, grease, flux, dirt and other contaminants from contacts, printed circuit boards, switches, motors, precision instruments, etc. It is highly inflammable (contains isohexanes and isopropyl alcohol) and is available in 16-ounce cans that deliver a stream spray.

Contact: Amrep Inc., 990 Industrial Park Drive, Marietta, Georgia, GA 30062, United States of America. Tel: +1 (770) 422 2071; Fax: +1 (770) 422 1737

E-mail: info@amrep.com

Website: www.amrep.com

Aqueous stencil/misprint cleaner

Alpha Metals Inc., New Jersey, the United States, offers HYDREX A-Plus Aqueous Cleaner that can effectively clean uncured surface mount device (SMD) adhesives and solder pastes from stencils and misprinted assemblies. A-Plus Cleaner is a safe and non-inflammable blend of select non-ionic surface-active agents and de-ionized water. It is recommended as cleaning agent for electronics manufacturers who want:

To clean both SMD adhesives and solder paste in one cleaning process and cannot heat the cleaning solution;

To reduce or eliminate VOC emissions;

To reduce odour in the workplace; and

To reduce or eliminate inflammable or combustible solvents.

The zero-ODP, zero-GWP, clear, water-white liquid has a pH (10 per cent solution) of 6.0-7.0 a specific gravity (at 25C) of 1.01 and viscosity (at 25C) of about 1 cPs. It is available in 5 gallon (19 l) and 55 gallon (208 l) containers.

Contact: Alpha Metals Inc., World Headquarters, 600 Route 440, Jersey City, New Jersey, NJ 07304, United States of America. Tel: +1 (201) 434 6778; Fax: +1 (201) 434 7508

Website: www.alphametals.com

New zero-ODP degreaser

Global Plexus Sdn. Bhd. of Malaysia offers Electro, a specially formulated selection of rapid-drying solvents. Eelectro is a zero-ODP cleaner and degreaser for the removal of oily and greasy dirt and moisture. It is an effective replacement for 1,1,1-trichloroethane or similar solvents banned or restricted under the Montreal Protocol, and may be safely used on metals, plastics and even many painted surfaces. It finds use in cleaning and refurbishment of electric switchgear, motors and similar equipment, clean-up of hydraulic and pneumatic equipment, removal of temporary protective coatings, etc. Electro, which is a blend of highly refined hydrocarbon and oxygenated solvents, is by far the quickest evaporating solvent degreaser available today. It is a clear, water-white liquid virtually insoluble in water, and is presented in an aerosol can that uses a hydrocarbon propellant.

Contact: Global Plexus Sdn. Bhd., A-25 1st Fl., Jalan IM 3/11, Bandar Indera Mahkota, 25200 Kuantan, Pahang Darul Makmur, Malaysia. Tel: +60 (9) 5735623; Fax: +60 (9) 5735562

E-mail: admin@globalplexus.com.my

Website: www.globalplexus.com.my

Distillable solvent in-line cleaners

Micro Care Corporation of Connecticut, the United States, offers Ionox BC, a patented non-linear alcohol defluxer formulated for cold cleaning. Ionox BC is often used as a stencil cleaner or a room-temperature wiping solvent because of its strong cleaning action, high flashpoint and zero ODP. It quickly dissolves oils, grease, ionic deposits, organic residues, silicones, inks and paints. Non-corrosive and ESD-safe, Ionox BC is typically used to clean tightly-spaced through-hole assemblies, surface mount boards, hybrids and even bare boards.

Ionox BC is primarily a non-linear alcohol made from renewable resources such as waste sugar cane, rice and wood by-products. This powerful ozone-safe alternative is completely volatile and will evaporate without residues. It is safe on most cured epoxies, flex laminates, solder masks, and most metals and alloys, but may attack some elastomers and polycarbonates.

Contact: Micro Care Corp. 595 John Downey Drive, New Britain, CT 06051, United States of America. Tel: +1 (860) 827 0626; Fax: +1 (860) 827 8105

E-mail: techsupport@microcare.com

Website: www.trek-ind.com

Low-foam aqueous cleaners

ITW Rocol North America, the United States, has introduced a series of low-foam, biodegradable and recyclable aqueous cleaners for spray, immersion and ultrasonic applications. The Daraclean products, all liquid concentrates, include:

Daraclean-200 All-purpose, metal-safe (except 2000 & 7000 aluminium) alkaline cleaner with high pH for aggressive alkaline cleaning.

Daraclean-203 Heavy-duty caustic cleaner with non-silicate, non-phosphate formula for high-pressure and immersion cleaning ferrous metals.

Daraclean-236 Mild, all-purpose, neutral pH cleaner suited for removing buffing compounds and grease from metal surfaces.

Daraclean-257 Heavy-duty alkaline cleaner a blend of phosphates, organic surfactants, inhibitors and silicates especially effective on carbon, greases, oil and baked-on soil. It is multi-metal safe and effective on both inorganic and organic soils.

Contact: ITW Rocol North America, 3642 West Lake Avenue, Glenview, IL 60025, United States of America. Tel: +1 (847) 657 5278; Fax: +1 (847) 657 4897.

Website: www.rocolnorthamerica.com

Website: www.itwfpg.com

Ultrasonic vapour degreaser

Branson Ultrasonics Corporation, based in the United States, offers its BTC-200 ultrasonic vapour degreaser. The two-sump ultrasonic vapour degreaser is ideal for use with traditional solvents like trichloroethylene and methylene chloride, as well as many of the newer materials including HCFC, HFC, HFE, n-propyl bromide, AK-225, etc. With an 18 litre solvent capacity, the compact BTC-200 is ideal for use at individual production workstations or as a tool to develop processes for larger equipment.

The BTC-200 is designed to comply with EPA environmental regulations on solvent emissions. Some of its more important features are:

Freeboard ratio of 100 per cent minimizes diffusion losses due to drafts;

Peripheral condensing coil efficiently condenses solvent vapours, minimizing emissions;

Captured sliding cover eliminates drafts and help seal the unit during periods of inactivity;

Internal water separator keeps all solvents within the unit at all times; and

High vapour level sensor to prevent solvent boil off and low solvent sensor to prevent heater damage.

The controls are 24 V with digital readouts and the machine is constructed in 304 stainless steel.

Contact: Branson Ultrasonics Corporation, P.O. Box 1961, Danbury, CT 06813-1961, United States of America. Tel: +1 (203) 796 0572; Fax: +1 (203) 796 9802.

Website: www.bransoncleaning.com

AEROSOLS

Boron nitride aerosol

Combat Boron Nitride Aerosol, from Saint-Gobain Advanced Ceramics in the United States, is an aerosol spray consisting of boron nitride powder dispersed in anacetone carrier and carefully compounded with a small amount of binder to facilitate adherence. The propellant used is ozone-friendly and non-carcinogenic but inflammable. Combat Boron Nitride aerosol deposits a thin film (0.0005") of boron nitride powder, which is very lubricious, produces an excellent anti-stick surface and will act as an anti-oxidation barrier for up to 850C. It is chemically inert to most organic and corrosive agents, and is not wet by molten glass or slag. Combat Boron Nitride aerosol may be used as a coating for:

High-temperature release (crucibles, moulds, transition plates);

High-temperature lubrication;

Corrosion resistance to molten metal, molten glass and slag;

Anti-oxidation barrier; and

Anti-stick barrier during hot-pressing.

The aerosol comes in 12 oz cans. The approximate coverage of one can of aerosol is 75 sq. ft.

Contact: Saint-Gobain Advanced Ceramics, Boron Nitride Products, 168 Creekside Drive, Amherst, NY 14228-2027, United States of America. Tel: +1 (716) 691-2052; Fax: +1 (716) 691-2090.

Website: www.bn.saint-gobain.com

Ozone-safe pressurized duster

Electron Microscopy Sciences of the United States has introduced a new line of 100 per cent ozone-safe pressurized duster products. This new formulation difluoroethane (Formula S) delivers pure, moisture-free blasts that remove dust and dirt particles. Formula S is considered non-inflammable and safe for normal use (though it contains some inflammable elements). Products in this range give 57 per cent more blasts per ounce and include:

Dust-Off FGSA with a nozzle designed to prevent formation of droplets;

Dust-Off Plus, which comes with a patented 360 Vector Valve; and

Dust-Off XL (DPSXL), which is the first safe for the environment disposable pressurized duster.

For special applications, where inflammable elements are prohibited, the dusters are available with Formula N containing tetrafluoroethane. The new canisters will yield 20 per cent more blasts than the old ones. The models available in the Formula S are available in this range also. Another range Dust-Pro System containing tetrafluoroethane is available for 120 psi dusting (upright position) and chilling (inverted position) operations.

Contact: Electron Microscopy Sciences, P.O. Box 550, 1560 Industry Road, Hatfield, PA 19440, United States of America. Tel: +1 (215) 412 8400; Fax: +1 (215) 412 8450

E-mail: sgkcck@aol.com

Website: www.emsdiasum.com

HFA-propelled MDI

Inyx Inc., a specialty pharmaceutical company based in the United States, has added to its development portfolio of proprietary products HFA-MDI delivery of salbutamol, which is the most widely prescribed short-

term bronchodilator medication to treat breathing disorders. This follows positive results from a two-year stability study for a non-ozone-depleting hydrofluoroalkane (HFA) propelled salbutamol metered dose inhaler (MDI), utilizing Inyxs patented lipid-binding technology for enhancing the delivery of inhalation-therapy drugs. HFA is the prime substitute for the CFC gas propellant used in MDI sprays that deliver approximately 95 per cent of all asthma medication.

The results of the successful two-year study on the salbutamol HFA-MDI are part of the intellectual property associated with the patented lipid technology that Inyx acquired in September 2004 from Phares Technology BV, the parent company of Phares Drug Delivery AG of Muttenz, Switzerland. Inyx plans to start scale-up studies on the salbutamol HFA formulation in early 2005. It has already commenced feasibility studies on HFA-MDI formulations of various lipid-enhanced combination drugs.

Contact: Inyx Inc., 825 Third Avenue, 40th Floor, New York, NY 10022 , United States of America. Tel: +1 (212) 838 1111; Fax: +1 (212) 838 0060

E-mail: info@inyxinc.com

Website: www.inyxinc.com

FOAMS

Silicone sponge using water as blowing agent

Dow Corning, the worlds largest manufacturer of silicone rubber products, has developed new closed cell silicone sponge technology that replaces the traditional reactive chemical blowing agents and volatile organic compounds as the expansion source. Silicone sponge materials are used in applications that require the benefits of siloxane polymers such as low temperature flexibility, thermal insulation, electrical insulation and UV and ozone resistance. In addition, sponge rubber is lightweight, provides damping effect, and offers substantial cost reduction when compared with a compact elastomer because less material is used. Adding a chemical blowing agent to a rubber compound produces conventional silicone sponge, but these blowing agents may produce toxic by-products. Dow Cornings Silastic sponge technology employs water as the blowing agent to create uniform cellular sponge structure that can be used in food contact applications.

Website: www.dowcorning.com

Pentane metering unit

Krauss-Maffei, Germany, offers pentane metering units for handling pentane during the manufacture of polyurethane products. Pentane-blown PU systems are used in the refrigeration industry and in pipe insulation. For example, cyclopentane, is a favoured blowing agent. However, the inflammable gas needs careful handling. Krauss-Maffeis Pentamix allows controlled processing of pentane. The Pentamix polyol/pentane premixing unit takes precisely defined volumes of polyol and pentane from the day tanks, mixes them and holds them in readiness for production in a specially designed container. It has:

Special serial piston pump with a separate leakage barrier pump for leakage control;

Axial piston pump with pressure monitoring for polyol;

Digital flow meter;

Gas warning sensor;

Static mixer; and

T3 explosion proof electrical components and housing.

The polyol/pentane containers are double-walled, blast pressure resistant and operate at pressures up to 145 psi.

Contact: Krauss-Maffei Kunststofftechnik GmbH, Krauss-Maffei-Strasse 2, D-80997 Mnchen, Germany. Tel: +49 (89) 8899-0; Fax: +49 (89) 8899-31 51

E-mail: info@krauss-maffei.de

Website: www.krauss-maffei.com

CO2 metering system

Battenfeld Gloucester Engineering Co. of Massachusetts, the United States, offers a carbon dioxide (CO2) metering system that allows precision control of C blowing agent into the primary extruder. Precise regulation of the foam blowing agent is essential to optimize foam sheet characteristics. The FoamCo2 high-pressure metering system has electronic flow control (less than 1 per cent variation), a two-stage gas intensifier pump that boosts CO2 gas pressure, regulatory valve system, and Nema 12 enclosure with easy-to-use pressure gauges and digital displays.

Key specifications include:

Maximum output capacity of 60 lb/h (about 27 kg/h);

Maximum pressure capacity of 5,000 psi;

Pneumatic operation at 80 psi; and

Dimensions of 122 cm (H) 122 cm (W) 46 cm (D).

Contact: Battenfeld Gloucester Engineering Co., Blackburn Industrial Park, Gloucester, MA 01931-0900, United States of America. Tel: +1 (978) 2811800; Fax: +1 (978) 282 9111.

Website: www.smsk.com

Slabstock machine

RIM Polymers Industries Pte. Ltd. of Singapore is offering slabstock foaming machines manufactured by Laader Berg, Norway, which has been in the polyurethane industry for 40 years. The Maxfoam slabstock machines produce giant rectangular foam blocks, using the Maxfoam process. RIM Polymers can also supply Maxfoam machines with NovaFlex technology for production using carbon dioxide as blowing agent. This technology can be retrofitted to existing Maxfoam plants.

The Laader Berg concept produces large, high, flat-topped blocks, suitable for further processing into a wider range of products. The method is economical (8-12 per cent savings) due to minimum wastage, and offers excellent density distribution. The machines are easy to operate and require only 3-4 operators.

Contact: RIM Polymers Industries Pte. Limited, 209 Henderson Road, Henderson Industrial Park, Singapore 159551. Tel: +65 6278 3288; Fax: +65 6271 0426

E-mail: rim_polymers@cehgp.com.sg

Website: www.rimpolymers.com

Blowing agent metering system

Direct gas foaming can give expanded polypropylene (EPP) a performance edge over expanded polystyrene (EPS). The EPP foaming process offers materials with higher temperature resistance (up to 130C), microwaveability, improved stability and durability, smooth surface, and excellent recycling properties. Gas metering systems from Haskel Australia Pty. Ltd. meet all of the EPP foaming process demands.

Haskel air-driven pumps and boosters are used for injection of CO2, butane, nitrogen and pentane as blowing agents. Haskel systems, which can pump blowing agent in gaseous or liquid form, control flow from the point of bulk storage to the point of injection. Key specifications include:

Maximum pressurization of 5,800 psi (gas booster for gases, pump for liquids);

Closed loop mass flow control; and

Injection and system pressure controls.

Contact: Haskel Australia Pty. Ltd., P.O. Box 267, Salisbury, Queensland 4107, Australia. Tel: +61 (7) 3277 9118

E-mail: info@haskel.com.au

Website: www.haskel.com.au

HALONS

Drop-in replacement for halons

PT. Hartindo Chemicatama Industri, Jakarta, Indonesia, offers AF11E, a drop-in replacement for halon BTM 1301 and halon BCF 1211. With an ODP of 0.016, GWP of 0.018, AF11E has the lowest environmental impact of most halocarbon alternatives. Key features include:

Suitable for Class A (surface), B and C fires;

Lowest HF levels among similar products;

Minimum 5 per cent design concentration;

LPC (UK)-tested (BS 5423 standard) halon replacement; and
]
Safe for use on electrical equipment.

The company also offers AF11E range of portable fire extinguishers, which are available in sizes ranging from 300 g aerosol can to 100 kg mobile trolley unit.

Contact: PT. Hartindo Chemicatama Industri, Jalan Agung Utara 1, Blok A2, No. 43, Sunter, Jakarta 14359, Indonesia. Tel: +62 (21) 651 9488; Fax: +62 (21) 6530 5432

E-mail: office@hartindo.co.id

Website: www.hartindo.co.id

Charged water mist for fire fighting

Misting sprays are effective in quenching fires with considerably less water and little water damage. However, like all uncharged sprays, mist sprays are unable to convey droplets to cloistered areas where fires often break out. In contrast, in charged sprays, the charged droplet trajectories are controlled by mutually induced electrical forces that automatically drive them to grounded surfaces no matter how distant these surfaces are from the nozzle. This ability could potentially make charged water mist spray a replacement for halon.

Charged Injection Corporation (CIC) of the United States, working under Navy sponsorship, has developed a number of nozzles that are capable of providing high flow rate charged sprays. All CIC nozzles involve the same concept the driving of free charge (electrons) into a passing fluid. Once charged, the fluid predictably atomizes and self-disperses. CIC is under Navy contract to develop an electrostatic water mist nozzle using an electron gun to drive charge directly into water streams. This patented Spraytron technology uses a groundnut-sized electron gun as the source. This technique opens the way to the development of nozzles that are capable of operating at any flow rate.

Contact: Dr. Arnold Kelly, Chief Engineer, Charged Injection Corporation, Monmouth Junction, New Jersey, United States of America. Tel: +1 (908) 274 1470; Fax: +1 (908) 274 1454

E-mail: spraytron@aol.com

Website: www.olcp.com

Halon reclamation

In Australia, DASCEM Holdings Pty. Ltd. manages the national collection of portable halon extinguishers and reclaimation of halon from them by decanting the process of halon recovery (from the cylinder), filtration and reclamation. The recovery process is the removal of halon and nitrogen used to pressurize the cylinders in both the liquid and vapour phases from pressurized cylinders.

Two methods of halon recovery are used at the Australian National Halon Bank: Cylinder Piercing Technology (CPT) and Defender Units (DUs). Computer-controlled CPT is used to recover halon from portable fire extinguishers and fixed-system cylinders. Individual cylinders are securely clamped into a horizontal position and pierced through the sidewall. The halon flows through the centre of the piercing device and into the CPT unit, which is fully sealed to avoid atmospheric exposure. DUs are selectively used to recover halon from cylinders with head valve actuation if the cylinder is required for reuse. Quick fit couplings are used to connect halon cylinders to DUs, which act as pumping stations recovering the contents of the cylinder through the head valve. The recovery system removes a minimum of 99.5 per cent to the theoretical limit of 99.9 per cent of the liquid and vapour contents of the cylinders.

The impurities in the mixture of halon and nitrogen recovered are removed during the filtration process. The reclamation process involves separating the nitrogen from halon using a carbon dioxide cold-bath cooling system. Reclaimed halon is fully analysed using gas chromatography to ensure conformance with international specifications and transferred to bulk tanks for storage or eventual destruction.

Website: www.dascem.com.au

FUMIGANTS

Methyl disulphide-metam sodium for weed control

Researchers at the Auburn University & Alabama Agricultural Experiment Station, the United States, have tested combination treatments of methyl disulphide (MDS) and metam sodium (MS) for weed control. Dr. R. Rodriguez-Kabana and Dr. Lee Simmons studied the herbicidal properties of MDS-MS combinations using sandy loam soil (pH 6.5, organic matter <1 per cent) from a cotton fields. The soil was infested with a variety of weed species principal among which were crabgrass (Digitaria sanguinalis), pigweed (Amaranthus spp.), morning glory (Ipomea spp.), sicklepod (Cassia tora) and yellow nutsedge (Cyperus esculentus). MDS and MS were delivered as a drench in water. MS was applied using the Vapam HLR formulation at rates of 6.4, 13.1, 26.2 and 39.2 mg a.i./kg soil. These rates were applied with MS alone and in combination with MDS at 750 mg a.i./kg soil. MDS was also applied alone at rates of 250, 500, 750 and 1000 mg a.i./kg soil. Each treatment was represented by 7 replications (pots) in a randomized, complete block design. Each pot contained 1 kg of

soil. The pots with soil were covered with transparent polyethylene bags immediately after treatment. The bags were removed after 10 days and the number of weeds was noted at 10, 18, 25, and 39 days after application of the chemicals. Combination treatments resulted in superior control of all weed species compared with MDS or MS alone.

A similar study was carried out on the same plant species using combinations of MS and propylene oxide (PO). MS was applied using the Vapam HLR formulation at rates of: 6.4, 13.1, 26.2, and 39.2 mg a.i./kg soil. These rates were applied with MS alone and in combination with PO at 300 mg a.i./kg soil. PO was also applied alone at rates of 100, 200, 300 and 400 mg a.i./kg soil. Each treatment was represented by 7 replications (pots) in a randomized, complete block design. The pots with soil were covered with transparent polyethylene bags immediately after treatment. The bags were removed after 8 days and the number of weeds was counted at weekly interval for 3 weeks. In this case too, combination treatments resulted in superior control of all weed species compared with MS or PO alone.

Results of these studies suggested strong synergy for herbicidal activities between the two compounds. The data supported the possibility of using MDS-MS combination or MS-PO combination for development of alternatives to methyl bromide for soil fumigation.

Contact: Dr. R. Rodriguez-Kabana, Department of Entomology and Plant Pathology, Auburn University & Alabama Agricultural Experiment Station, Auburn, Alabama 36849, United States of America.

E-mail: rrodrigu@acesag.auburn.edu

Website: www.mbao.org

Efficacy of MB alternatives in vineyard

Alternatives to methyl bromide for perennial crops must demonstrate efficacy not only for the growing season but throughout the early growth and fruiting years. A study led by scientists from the Agriculture Research Centres of the United States Department of Agriculture conducted field trials of vineyards planted in 1998, 2000 and 2001.

The investigation covered three grape variety/rootstock combinations own-rooted Thompson Seedless, Merlot on Harmony rootstock and Merlot on Teleki 5C rootstock. Soil samples were collected to a depth of 24 inches from each treatment/rootstock combination, processed by sugar flotation-centrifugation, and populations of root knot (Meloidogyne spp.) and citrus (Tylenchulus semipentrans) nematodes monitored. The investigations provided the following conclusions:

Iodomethane, drip-applied Telone, and InLine appeared to be good alternatives to methyl bromide for vineyard replant when both root knot and citrus nematodes are present. However, use of these chemicals is restricted by regulations.

Root knot nematode populations on Harmony rootstock are undetectable after 6 growing seasons, but populations of the citrus nematode are higher on Harmony than on Thompson Seedless or Teleki 5C.

After four growing seasons, significant reduction in root knot and citrus nematode populations was not

observed from long-term fallow treatments for vineyard replants.

Contact: Dr. S. Schneider, United States Department of Agriculture, Agriculture Research Centre, Parlier, California, CA 93648, United States of America.

Website: www.mbao.org

VIF mulch in aid of fumigant reduction

Growers depend on methyl bromide (MB) as part of the plastic mulch production system because it provides economical management of nematodes, most soil-borne diseases and weeds, especially yellow and purple nutsedge (Cyperus esculentus and C. rotundus). Agricultural researchers in the United States report that the use of virtually impermeable film (VIF) technology allows the use of significantly less MB, which will serve to achieve lower MB emissions from the treated soil while ensuring the same efficacy. Telone C35 would also work under the same system, to provide an alternative to growers whose interest is in the control of nematodes and soil-borne pathogens.

In tomato fields, the interaction between fumigant treatments and mulch types against nutsedge was found to be highly significant. In general, plots treated with MB at all rates provided excellent control of nutsedges, with the exception of MB applied at 79.4 kg/acre under PE mulch. Plots treated with Telone C35 at both the 98.5 and 132.5 litres/acre rate under VIF film provided adequate control of nutsedges. Other than the two highest rates of MB (117 and 157.8 kg/acre), only Telone C35 applied at a 132.5 litres/acre rate under PE film gave any reduction of weeds as compared with untreated plots. These data suggest that VIF mulch effected a greater reduction in the number of nutsedge plants than PE mulch. Similarly, the interaction between fumigant treatments and mulch types was highly significant in root knot nematode galling. The data suggested that the use of VIF film enhanced nematicidal activity of all three rates of MB and C35 at 132.5 gallons/acre as compared with traditional PE mulch.

VIF mulch helped retain lethal concentrations of MB for effective control of nutsedges in strawberry fields also, with half (196 kg/ha) that of standard application rate (392 kg/ha). There were no reports of reduced yield or plant growth owing to reduced rate of MB application when VIF was used as mulch.

Website: www.mbao.org