It's a Niche, Natch:

Walnut shells used for abrasive media
Courtesy of Eco-Shell, Inc.

A Review of Specialty Abrasives for Cleaning and Surface Preparation

by Lori Huffman, ***JPCL***

Gone are the days when a blast pot full of sand would solve any surface preparation problem. With the emergence of regulations designed to protect worker health and the environment, as well as the use of delicate substrates unsuited to aggressive surface preparation and processes that can't tolerate contamination by abrasive residues, specialty abrasives have found their niche in the cleaning and surface preparation arenas. But what do specialty abrasives do? Some clean and prepare surfaces without generating large amounts of dust, most remove coatings and surface contaminants from easily damaged substrates, and others minimize blasting waste.

The following article offers a brief review of specialty abrasives, including sodium bicarbonate, magnesium sulfate, sponge, dry ice, agricultural products, glass beads, and plastic media. Tables 1 and 2, reprinted in part from the U.S. Occupational Safety and Health Administration's "Silicosis in Sandblasters: Use Silica Substitutes" (and which appears on the OSHA website), give further details on some of the specialty abrasives discussed below.

Sodium Bicarbonate Abrasives

Sodium bicarbonate is used for coating removal, mold removal, fire restoration, and historic preservation, says Delia Downes, ARMEX® product manager for the Church & Dwight Company. Emerging markets for the abrasive include the preparation of softer substrates, such as composite materials and aluminum, which can be damaged by conventional cleaning methods. Sodium bicarbonate is also well suited to remanufacturing applications where cleaning, degreasing, and paint removal are achieved in one step.

Using sodium bicarbonate for restoration work.
Courtesy of Armex®

Downes' company introduced sodium bicarbonate to the surface preparation market in the late 1980s, spurred by the restoration of the Statue of Liberty. Despite some problems with the process, the company saw the potential for sodium bicarbonate as an effective abrasive for sensitive substrates, says Downes. In the years following the restoration project, the company "optimized the abrasive for productivity and performance and partnered with an equipment manufacturer to optimize the delivery system," she says.

Sodium bicarbonate abrasive is characterized by its sharp, angular particle shape, says Downes. The abrasive is extremely soft, with a Mohs hardness of 2.5 and also extremely friable. The abrasive doesn't damage the substrate and will not impart a profile (unless blended with hard grit abrasives). It is possible, however, to expose the original profile on the substrate. In critical component cleaning, the "one-pass" medium doesn't introduce contaminants to the substrate, and the water-soluble abrasive doesn't leave a residue that could interfere with later processes, she says.

Of course, sodium bicarbonate abrasive is not suitable for every job. The abrasive should not be used for applications requiring heavy profiling and the removal of heavy corrosion or jobs with no environmental restrictions, says Downes. Sodium bicarbonate is not

appropriate for flexible coatings. In applications where dusting can't be tolerated, sodium bicarbonate should not be used. Dust minimization is best achieved through the use of negative air, air scrubbers, and containment, says Downes. When conditions allow, water attachments on the nozzles of surface preparation equipment can spray a mist of water following the path of the sodium bicarbonate abrasive, facilitating suppression of the dust.

Sodium bicarbonate abrasive usually calls for specifically engineered equipment and operator training, says Downes. People familiar with air-driven equipment can understand the process, but finesse is necessary, she says.

Table 1: Some Alternatives to Conventional Abrasives*

Abrasive	Special Equipment	Properties
Aluminum Oxide	None Required (Usually Used in Cabinets or Rooms with Recycling Equipment)	Closely Sized Very Hard (MOH 8.5-9)
Baking Soda (Sodium Bicarbonate)	Yes (Meters Less Product/Min and Dries Air)	Natural (Flow and Rinse Agents Added) Water Soluble Non-Sparking Non-Flammable
Corn Cob Granules	Special Ventilation May Be Required in Enclosed Areas to Control Combustion	Medium Hardness (MOH 4.5) Non-Sparking
Dry Ice (Carbon Dioxide)	Dry Air Required	Natural Gas in Solid State
Garnet	None Required (Additional Components Required in Order to Recycle Media)	Very Hard (MOH 8) Very Heavy (S.G. 4.1) Subangular
Glass Beads	None Required (Usually used in Blast Cabinets with Recycling Equipment)	Manufactured of Soda Lime Glass
Nut Shells	Special Ventilation May Be Required in Enclosed Areas to Control Combustion	Soft Non-Sparking Natural Mineral Hard (MOH 6.5-7)
Plastic Media	None Required (Additional Components Required in Order to Recycle Media)	Soft Non-Abrasive Polyester, Urea, Melamine Varieties

**Drawn primarily from "Silicosis in Sandblasters: Use Siica Substitutes," The U.S. Occupational Safety & Health Administration, www.osha.gov.*

Table 2: Comparison of Selected Alternative Abrasives by Application*

ABRASIVE	APPLICATIONS	ADVANTAGES	LIMITATIONS
Aluminum Oxide	Cleaning Hard Metals (e.g. Titanium), Removing Metal, Etch Glass, Carve Granite	Recyclable	Must be Reclaimed and Reused for Economy
Baking Soda (Sodium Bicarbonate)	General Paint Removal, Stripping Aircraft Skins, Cleaning Surfaces in Food Processing Plants, Removing Paint from Glass	Less Material Used/Less Cleanup, Low Nozzle Pressures (35-90 PSI), Non-Sparking, Water Soluble	May Damage Soft Brick
Corn Cob Granules	Deburring, Paint & Rust Removal from Wood & Metal	Low Consumption, Low Dust Levels, Biodegradable	Does Not Create an Anchor Profile
Dry Ice (Carbon Dioxide)	Cleaning Aircraft Parts Cleaning Exotic Metals	No Residue Remains Minimal Cleanup	Noise, Blast Angles for Some Brands
Garnet	General Paint, Rust & Scale Removal from Steel	Lower Nozzle Pressures (60-70 PSI) Low Dust Levels, Fast Cleaning Rates, Can be Recycled 6-7 Times	Salt Content, Cost (depending on user's location)
Glass Beads	Cleaning & Polishing, Deburring	Low Free Silica Uniform Size and Shape, Recyclable	Does Not Create an Anchor Profile
Nut Shells	Cleaning Soft Materials (e.g. Aluminum, Plastic, Wood) Cleaning Surfaces in the Petroleum Industry	Provide High Luster Polished Surface High Removal Speed, Non-Sparking, Low Consumption	Non-Etching, Potential Fire Hazard
Plastic Media	Cleaning Soft Metals & Composites Cleaning Metal Fabric Screens	Inert, Recyclable, Does Not Damage Metal Surfaces, Low Nozzle Pressures (20-40 PSI)	Anchor Profile Limited to Soft Substrates (e.g., Aluminum and Plastic)

**Drawn primarily from "Silicosis in Sandblasters: Use Silica Substitutes," www.osha.gov.*

Magnesium Sulfate

Another water-soluble abrasive came on the market in 2001, says Pete Mitchell, vice president of Universal Minerals. Kieserite, also known as magnesium sulfate, can be used in applications where sodium bicarbonate abrasive is typically employed. The abrasive is suitable for wet and dry processes, including coatings removal and tank stripping in the petrochemical industry, automobile and boat restoration, and graffiti removal, among other applications.

The benefits of the abrasive include its pH-neutral nature, which allows its use around sensitive foliage, and its productivity, which is two to three times that of sodium bicarbonate, owing to its 3.5 Mohs hardness, says Mitchell. Additionally, the abrasive is able to remove coatings that sodium bicarbonate can't strip, such as epoxies, he says. Because it is pH neutral, kieserite does not require the neutralization necessary in the sodium bicarbonate blasting process.

Kieserite abrasive can be run through most sodium bicarbonate blast equipment, as well as conventional blast equipment. Operators familiar with sodium bicarbonate blasting and convention-

Other Specialty Abrasives

by Brian Goldie, PCE

Other specialty abrasives, some used for protective coatings work and some not, are reported on below.

Garnet, more common today than it used to be, offers a number of advantages over other abrasives, says Richard Paddison, Wolverhampton Abrasives, UK. Because it is relatively cheap when used close to where it is quarried—mainly Australia, India, the USA, and South Africa— it is often used as an expendable abrasive in these areas. In Western Europe, however, cost tends to rule it out as an expendable abrasive except in environmentally sensitive areas where its low dust qualities can be attractive. It should generally be regarded as a recyclable abrasive for use predominantly on non-ferrous substrates as an alternative to aluminium oxide, but costing around one-third of its price. The number of cycles depends on blasting pressure and the original particle size. At low blasting pressures it can be recycled up to 10 times, depending on the substrate and other factors—not as many as aluminium oxide but still enough to provide reasonable economy for particular applications, according to Paddison.

A natural mineral, garnet is very inert and reacts with very few other materials so it can be used on a variety of ferrous and non-ferrous substrates. Metallic abrasives that become trapped in inaccessible areas—for example, between riveted panels—may well corrode if they are not adequately coated after blasting. Garnet has therefore been used successfully on structures like ship decks, where the large amount of equipment on the deck creates many voids where grit can be trapped.

Garnet has the highest specific gravity of all the natural and synthetic abrasives used commonly on site. Its high bulk density also means that a greater weight of material per cubic meter can be disposed of when compared to other abrasives.

Users should bear in mind that, even after washing, garnet is likely to be near the top end of the ISO 11126 specification for soluble salts.

Sintered bauxite, like garnet, can be used as an alternative to aluminium oxide, says Paddison. The material is produced from heat treating natural bauxite without melting and fusing it, as happens in the manufacture of aluminium oxide. Although it is nearly twice as expensive as aluminium oxide, it lasts three times as long. It is not used much in the protective coatings industry, because for some applications it will not roughen the substrate and can have a peening effect on metallic substrates.

However, Paddison adds, a similar material, calcined bauxite, is available as a grit and represents a cheap, versatile, and efficient alternative to aluminium oxide for many applications. Because of its hardness, a mesh size lower than normally used for aluminium oxide will achieve the same profile. As with bauxite shot, dust levels are very low, and the product has excellent recycling performance.

In addition to walnut shells, discussed in the accompanying article, agricultural or vegetable abrasives include olive stone and peach stone, which are very soft, Paddison says. They are generally used for polishing or de-flashing applications in vibratory finishing machines. However, they can also be used in air abrasive units where the coarser grades are capable of removing carbon and similar deposits with very little damage to the substrate. Because of their composition, it should be remembered that most vegetable abrasives leave an oily deposit. Relatively benign and flammable, vegetable abrasives can be particularly useful in chemical plants if spent abrasive is difficult to remove. The vegetable abrasive will be burnt away at the normal plant operating temperatures. Their gentle cleaning performance makes vegetable abrasives highly suited to many cleaning applications where minimal damage to the substrate can be tolerated.

In addition to the abrasives that Paddison discussed, several other specialty media bear a quick overview.

Aluminium oxide is extremely hard and has a sharp profile that will cut even the hardest metals. It is one of the most commonly used abrasives in the finishing industry because of its cost and the number of times it can be recycled. It is used to clean parts in the aerospace industry, and it is used before metallizing or plating parts.

Ceramic beads are harder than glass beads and are chemically inert. They have a very regular size and shape and produce a satin finish. They are used for cleaning stainless steel and non-ferrous metals.

Glass grit is produced from crushed recycled glass, is lighter than glass beads, and produces a very bright surface because of its angular shape. It is also inert and contains no free silica. It is especially useful for preparing aluminium, brass, copper, and stainless steel.

al dry blasting easily adapt to blasting with kieserite, Mitchell says.

Sponge

Sponge blasting was developed in the late 1980s, first as a high production alternative to hand work and second (with the incorporation of abrasives) as a dry, low dust, abrasive blasting process, says Tony Anni, Sponge-Jet, Inc., marketing manager. Sponge abrasive is a composite of conventional abrasives and a sponge-like polymer. The abrasive component of the porous composite can be varied to allow for different applications, from gentle cleaning and removal of contaminants to profiling of substrates, says Anni. Among the abrasives used are aluminum oxide, metal grit, calcium carbonate, melamine, plastic urea, glass bead, staurolite, and garnet.

Sponge abrasive features low dusting because the urethane sponge component suppresses and entraps dust at the point of generation, says Anni. The polymer portion of the abrasive extends the life of the friable abrasive portion, reducing the break-up of the abrasive and the generation of more dust. Because of its large particle size, sponge abrasives can be separated many times for reuse, he says. With the many abrasives that can be used in the composite, sponge abrasive can create profiles from 0 to 4 mils (0 to 100 micrometers). In addition, sponge blasting has been shown to remove chlorides and other contaminants more effectively than conventional abrasives.

According to Anni, sponge abrasive is best used in environments and applications where its process benefits are needed. It is used in the marine, offshore, historic restoration, railcar, lead-based paint abatement, and general manufacturing industries. Sponge abrasive can be used to selectively strip coatings from sensitive substrates, and it can also be used to strip hard-to-remove materials such as polyurea and elastomeric coatings.

Anni mentions three limitations of sponge abrasive: the need for special equipment to handle the larger abrasive size, the higher cost of sponge abrasive as compared to conventional abrasives (offset, however, by low dusting, low rebound, and waste minimization benefits), and the need for management of the working mix to optimize dust suppression and production rate.

Sponge blasting uses a modified blast pot equipped with auger-based technology to control media flow. Given the specialized equipment necessary for the abrasive, operator training is recommended but not necessary for the effective use of the media, Anni says.

Dry Ice

Dry ice blasting was introduced to the surface preparation market in 1986, according to information presented on the website of Cold Jet, LLC. Dry ice media is available in the form of pellets, nuggets, or blocks. As noted in literature on dryiceinfo.com, the dry ice particles (at a temperature of -109 F [-79 C]) are propelled from the nozzle of dry ice blasting equipment using compressed air, whereupon they impact the surface and, through a combination of energy transfer and thermal shock, cause coatings or contaminants to pop off the surface. The dry ice particles sublimate, converting directly from a solid to a gas, leaving only the removed coatings or surface contaminants as waste from the process.

David Norton, owner of Norton Sandblasting Inc., recommends dry ice blasting for the removal of dirt, grease, oils, soot, mold, and poorly adherent coatings, rather than for the removal of well-adhered coatings. The process is widely accepted in the cleaning of injection molds, he says, and is also employed in the aerospace, automotive, electrical, fire restoration, food and beverage, and mold remediation industries, among others.

Dry ice blasting requires the use of specialized equipment. Norton says that although operators need to familiarize themselves with the equipment, it is not complicated to use.

According to the dryiceinfo.com website, dry ice blasting has a few drawbacks: the dry ice blasting process is noisy, requiring ear protection for workers; cleaning can only be effectively achieved in "a straight line of sight from the Dry Ice jet nozzle;" and significant amounts of carbon dioxide are released during the process, so that enclosed environments must be ventilated for safety.

Two of these limitations have been countered with new equipment developments, says Nicole Fenyo, marketing director, Europe, for Cold Jet, LLC. A new dry ice blasting machine blasts at air vol-

umes as low as 12 cfm, keeping noise levels well below the U.S. Occupational Safety & Health Administration's 85-dBA limit and allowing its use without the need for hearing protection. In addition, fan nozzles, angled nozzles, and pivoting head applicators allow dry ice blasting to be performed at various angles to the surface, rather than requiring the operator to blast standing directly in front of the surface.

A further development in dry ice blasting is its use in combination with xenon flashlamp technology to ablate coatings from aircraft skins and components, says Fenyo. The proprietary, patented process, developed by The Boeing Company, can selectively remove coatings from delicate metal or composite components without damaging underlying substrates, according to information available on the Flash Tech, Inc. website.

Agricultural Media

The grandfather of specialty abrasives, agricultural abrasive media go back more than 60 years, says Helen Cantrell, sales and marketing director for Eco-Shell, Inc. The most commonly used agricultural media are pecan shells, corn cob, rice hulls, walnut shells, and apricot shells, she says.

Agricultural media are considered to be soft abrasives, but they can provide aggressive cleaning, Cantrell says. Propelled by conventional blasting equipment at low pressures (50 to 80 psi), the abrasives are used in applications from polishing soft metals to cleaning fiberglass, plastic, concrete, aluminum engine components, and electronic components, among others.

Agricultural abrasives can remove paint from automobiles and carbon build-up from engine parts. But they can also clean delicate substrates without etching, scratching, or changing their dimensions, she says.

These abrasives are best suited for projects where there is a desire for waste minimization and low dust. Spent abrasives can be disposed of in a non-hazardous site or used as soil amendments, assuming the blasting debris doesn't contain the remnants of hazardous coatings, says Cantrell.

One-pass in nature, agricultural abrasives may be more costly, and their applications may not be as well recognized as conventional abrasives, Cantrell says.

Glass Beads

Surface preparation with glass beads has been performed in some finishing applications since the 1960s, says Norton. Machine shops and engine shops have long used the process to give a bright finish to machined parts without changing the tolerances of the metal.

Glass beads are round abrasives that, when propelled at low pressures (between 60 and 70 psi), remove surface contaminants and coatings by impact from metals such as steel, aluminum, and bronze. According to Kramer Industries' web site, glass beads are made from lead-free, silica-free soda lime-type glass. The abrasive produces a smooth, bright finish on metals. If used at the correct pressure, glass bead abrasive shouldn't shatter in the cleaning process and can be recycled for reuse. (A conservative estimate for recycling is 8 to 10 cycles, Norton says. The Kramer Industries' website estimates 30 cycles.)

Typically, glass beads are paired with conventional equipment in blast cabinets and blast rooms for the cleaning of smaller parts and the removal of paint and rust. Glass bead blasting yields a peened surface on metal, which is not an ideal surface for painting, Norton says. According to Kramer Industries, the abrasive can hone, polish, peen, blend, finish, debur, and clean light foreign matter.

Glass bead is too expensive to be used

as a one-pass abrasive. And, although it can achieve an SSPC-SP 5, White Metal, finish, it does not prepare the substrate as quickly or remove heavy coatings as well as angular grit.

Plastic Media

The first market where plastic abrasives found wide use was the aircraft industry in the late 1980s, says Norton. Typically produced in a blocky, angular shape (but also available in spherical form), the abrasive is a soft material that can remove coatings from delicate substrates without profiling the surface.

Plastic abrasives have found a niche in the surface preparation of aircraft skins, and possibly even greater use for aircraft components and support equipment. These abrasives are also used in the cleaning of injection molds, in deburring applications on softer metals, and in the cleaning of electrical contacts, Norton says. Plastic abrasives have been found to remove powder coatings faster than aluminum oxide abrasive, leading to market growth in the cleaning of reject powder-coated parts. In addition, when properly blended with another abrasive, such as aluminum oxide, plastic media can offer both fast cutting action and a White Metal finish, he says.

Because plastic abrasives are recycled (between three and four times during use), there is a risk that the media could become contaminated. Inadequate filtering can cause the media's non-aggressive cleaning action to quickly become aggressive, Norton says.

Although the abrasive requires minor modifications to standard blasting equipment, specialized operator training is not necessary, Norton says.

Conclusion

Over the years, each of these abrasive types has found its niche in various industries, providing cleaning and surface preparation solutions where there were once only problems.