Permanent road marking paint – an alternate approach

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Road marking paints are of two types: plastic emulsion paints and thermoplastic paints.

Plastic emulsion paints have some drawbacks. These are applied by spray or brush. I worked with these in early 1969 in my first job with the largest paint manufacturer in the country. We (some chemists) used to take trials on the road opposite the factory. There were certain drawbacks to these paints. They required clear road for at least 1 hour for the paint to dry completely. The abrasion resistance of the paint was also very limited. Therefore, the life, particularly on curvatures, was very poor, and repainting was necessary almost every three months. Best of the emulsion binders were styrene-acrylics or Vinyl Acetate Monomer (VAM)-acrylic emulsions. At best, the Minimum Film Forming Temperature (MFFT) was 10°C, in spite of the fact that the road surface could be hot most of the working hours. Very often, I saw contractors of the municipal corporation applying paints in the late hours of the night because it would not be possible to divert the main traffic in busy hours for one hour. To get to 10°C MFFT, most formulators had to add at least 50 g/litre volatile organic compounds (VOCs), which cannot get evaporated in less than one hour. So, the delay.

Work at UDCT

I became Professor of Paint Technology at UDCT in 1993. Till then thermoplastic hot melt paints had not been introduced in India. I had seen these in several countries I visited in the ten preceding years. One large company involved in manufacture and installation of road signals was interested in manufacturing these locally.

British standard specifications were available, which even described the composition. I do not have exact details, but it generally contained five ingredients:

1. Hydrocarbon resins (21-23%);
2. Glass spheres (spherical under the microscope, colourless, transparent with refractive index between 1.5-1.6, and between 100-1,400 microns in diameter.) (20%);
3. White quartz sand (20%);
4. Calcium carbonate mineral (10%); and
5. Titanium dioxide (8-10%).

As per the process, these components are dry mixed. For application, the mixture is heated to 200-250°C and is laid as a thick layer of about 4-5 mm thickness. The molten mass solidifies in a few minutes, and the road becomes usable. Due to sufficient thickness and high content of quartz, the abrasion resistance of the coating is good. Glass beads provide good visibility even in the night by reflecting the light from the vehicles back to the driver.

When the party tried to melt and lay it on the road, they faced several difficulties. The mixture did not melt uniformly and required more resin than specified to make it flow. The viscosity of the melt was too high and therefore, the thickness of the coat was also too high. That meant more paint consumption per km. By using suitable additives, the problem of flow was resolved. Analytical methods, not available in Indian standards, were developed at UDCT and the product was commercialised in 1994.

Over a period of time, many manufacturers started manufacturing and

application of the product commenced. As per specifications, the paint should retain its brightness, reflectivity, colour and thickness for five years. The suppliers agree with these specifications, knowing fully well that the road under the paint will not last more than a year!

All the major raw materials – hydrocarbon resins, glass beads and titanium dioxide – are not manufactured locally, and only calcium carbonate and quartz are locally produced. Thus, there is a heavy dependence on imports.

PET resin instead of hydrocarbon resin

Along with a coworker, I developed a road marking paint from waste Poly-Ethylene Terephthalate (PET) bottles. The resin could have performed as good or even better than hydrocarbon resins which are not stable to UV outdoors. The composition was also patented, but I could not find a suitable entrepreneur to commercialize it. The product is viable even today. Incidentally, our patent has expired.

Escalating requirement of paints

The total highway length in India

is 161,000-km. The Ministry of Road Transport and Highways is constructing 30-km of new highways every day. Thus, we are adding about 10,000-km of new highways every year. Even if a life of five years is considered for the road marking paint on concrete roads, we need to apply road marking paint on about 40,000-km of road every year. This number is increasing by 2,000-km each year. The requirement of paint for a 1-km strip of 75-mm width and 4-mm thickness works out to 1-tonne per line. A typical highway requires four continuous lines and two broken lines. This means the requirement of road marking paint for roads and maintenance is about 200,000-tpa (tonnes per annum). A 20% resin requirement implies we need about 40,000-tpa of hydrocarbon resin and about an equal weight of glass beads. These are too large quantities to be continuously imported.

Use of white cement as an alternative

I have been thinking about a solution to this problem and conceived an idea to reduce the imports of hydrocarbon resin, by basing the road marking paint on white cement. This would need some changes in application procedure.

Considering a large part of roads now being constructed is from cement concrete, there is a strong possibility of using road marking paint from white cement. When a concrete road is under construction, the road marking locations need to be decided within 24 hours of the casting of the road.

It would be very easy to place the strips right when the road is being laid. It should be possible to scrape out the surface of the freshly laid cement road as soon as it has initially set, in about 24 hours with the required dimensions, say 75-100 mm width and 4-6 mm thickness.

The compositions of a typical cement based road marking paint and that of a hydrocarbon resin based one is shown in Table 1.

In the composition, I have replaced all resin with the same volume of cement. The white cement is opaque enough not to require 10% TiO_2. So, the balance TiO_2 has been replaced by white cement to give better strength.

The dispersing agent used for cement-based castable compounds are also known as water-reducing compounds or superplasticizers. These help to reduce viscosity of the slurry, which is very important to reduce excess water in a castable. Cement reacts with only 22.5% water of its weight. It is the task of a concrete designer to keep the excess water as low as possible.

In the above formulation, only 12.6 parts of water that is added to make a slurry will react. Balance water remains unreacted and fills up some space when wet. On drying, the water leaves behind porosity, also known as "micro-voids". These seriously reduce the mechanical strength. While on tar roads life from the paint is expected for only about five years, on concrete roads life expectancy must be same as the road itself – typically 20 years these days.

The excess water, therefore, must be controlled and should be as low as possible. Typical products of third or fourth generation that are available as dry powders can be used. Most often, these are available as aqueous solutions and acceptance as a two-pack product may be difficult. It is advisable to use products of second generation like sulfonated melamine formaldehyde, sulfonated naphthalene formaldehyde or the ether carboxylate type polyacrylic or methacrylic acid sodium salts that are available as dry powders.

Typical packing of these products can also be like hot melt road marking paints, i.e., 25-kg or equal volume based on density.

Application technique

A hot melt road marking paint is applied on cured concrete or tar surface. The dry paint composition is melted by application of heat from burning a fuel like CNG or LPG. The

Table 1
Composition of road marking paint with hydrocarbon resin and cement

Ingredient	Hydrocarbon resin	Cement
Hydrocarbon resin	22	
Quartz	22	20
Calcium carbonate	24	
Glass spheres	20	20
Titanium dioxide (TiO_2)	10	2
White cement		56
Dispersing agent	2	2

mixture melts to a viscous liquid that is applied in a 3-4 mm thick layer by spreading through a slit of about 2 mm x 75-100 mm. Just like application of hot melt road marking paint, a white cement-based road marking paint can be applied on a freshly cast cement road surface. Some vibrations may be applied to make the paint flow easily.

If it is planned well, and application is done within 24 hours of casting, it will chemically bind with the cement road and display same life as the road itself. Unlike thermoplastic road marking paints, it would not project outside the road surface but will be the same level as the road.

Attractive economics

The cost of this paint would be only a fraction of the resin-based paint. It would be a step towards *Atmanirbhar Bharat* as I do not see any possibility of existing petroleum and petrochemical industries in India setting up a facility for manufacture of hydrocarbon resins due to constraints of size of plant and the market.

Manufacture of glass spheres is relatively easy [ref: Glass Beads for Road Markings and Other Industrial Applications, Tomasz E. Burghardt]. High quality glass is available in the country in adequate quantities, and getting the required 40,000-50,000 tonnes would not be difficult. The glass beads are manufactured by melting fine crushed glass particles in suspension in flue gases and cooling these in same suspended condition at 800-1000°C. In a reasonably large facility producing 40-50 tpd of glass beads, waste heat can be utilised.

Coupling brine electrolysis with mineral recovery can aid hydrogen economics

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Prof. Malshe's last month's column on improving the economics of green hydrogen manufacture, brought the following response from Mr. Lalit Vashishta.

Electrolytic hydrogen generation requires about 9 kg of ultrapure water for every kg of hydrogen produced, equivalent to 9 cubic meters of demineralized water per tonne of hydrogen. Since natural water sources – whether surface, ground, or seawater – contain dissolved salts, silica, and organic impurities, pre-treatment by reverse osmosis (RO) or seawater desalination is essential before electrolysis. The treatment cost for freshwater through a two-pass RO system is typically Rs. 50-60 per m³ (approximately $0.6-0.7/m³), while seawater desalination costs are higher at Rs. 70–90 per m³, translating to Rs. 0.07–0.09 per litre. This includes pre-filtration, membrane replacement, and energy input of about 3.5 kWh/m³. Consequently, the purified water cost adds roughly Rs. 0.5-0.8 per kg of hydrogen to the overall production cost – a small but important component in the economics of green hydrogen.

Desalination plants can be designed for value recovery from brine, turning a cost centre into a profit-generating operation. Seawater contains about 27-30 g/L of sodium chloride, 1.3 g/L of magnesium, 0.4 g/L of calcium, and 0.065 g/L of bromide ions.

Through selective precipitation and oxidation, valuable minerals such as magnesium hydroxide, calcium carbonate, and elemental bromine can be extracted. Typical recoveries yield approximately Rs. 2,000-3,000 per tonne for magnesium and calcium compounds and Rs. 150-200 per kg for bromine. For a 1 mld (million litres per day) desalination system, this corresponds to 1,040 kg/day of $Mg(OH)_2$, 360 kg/day of $CaCO_3$, 45 kg/day of bromine, and about 8 tonnes/day of industrial salt. With prevailing market prices of Rs. 12/kg, Rs. 6/kg, Rs. 180/kg, and Rs. 3/kg respectively, the total daily revenue from these by-products is approximately Rs. 46,740, translating to Rs. 14-15-lakhs per month.

This revenue stream is sufficient to offset the operational expenditure of desalination, estimated at Rs. 80,000-90,000 per day. If advanced brine concentration or nanofiltration systems are integrated, recovery efficiencies of magnesium and bromine can double, increasing revenue to Rs. 1-1.2-lakhs per day. Desalination effectively becomes a water-positive and economically self-sustaining process. For hydrogen production units located near coastal zones, coupling electrolysis with mineral recovery not only supplies the required ultrapure water but also generates additional income. Such integration transforms hydrogen plants into resource recovery hubs, enhancing circularity and improving the overall green hydrogen economics by 3-5%, turning treated water from a utility expense into a co-product advantage.