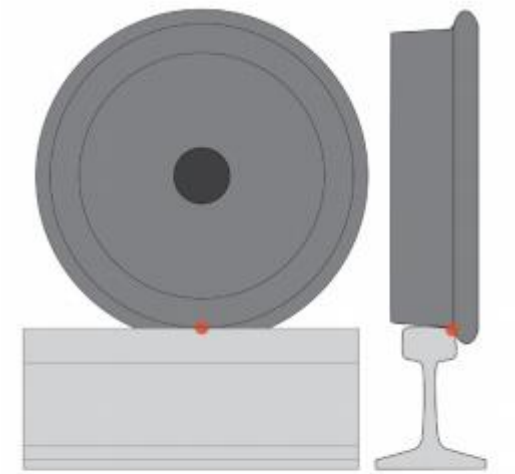
What causes the “black gunk” on wheels and rails?

Several years back, a model railroader submitted dirty track for an in-depth chemical analysis of this “black gunk” and reported the results on the MRH forum [mrhmag.com/node/3229]. Bottom line, this black gunk is mostly metal oxides formed from microarcing between the wheels and the rail. This contact point is quite small, as you can see in [1].



1. The electrical contact between wheels & rail is on the inside rail head and quite small.

Esssentially, the electricity flowing at this tiny contact point triggers a chemical reaction in the wheels and rails. The electrical current in effect “explodes off” metal alloy molecules from the wheels and rails. It oxidizes these metal molecules, forming a fine dark gray powder. So the key to slowing down the buildup of metal oxide is to inhibit the microarcing. The electrical contact between wheels & rail is on the inside rail head and quite small.

If you know something about the history of electric motors, you know they first tried copper motor brushes, but they arced badly and burnt out quickly. The solution was to use graphite because it inhibits arcing at the contact point! Interesting ... Further discussion with a chemist who also understood electrical contact cleaning such as in relays and switches, put me on to the concept of polar versus non-polar solvents. Once I delved into polar vs nonpolar solvents, something very interesting emerged. Polar vs non-polar Molecularly speaking, you can use what’s called the substance’s dielectric constant to derive its molecular polarity. The chemist told me that nonpolar solvents work best to both clean electrical contacts and to protect them by inhibiting microarcing. Apparently, polar solvent molecules get trapped in micropits of the metal surface, leaving an “electron charged” microscopic residue. This electron-charged polar residue encourages microarcing in the presence of an electrical current, quickly forming new metal oxides on the metal surfaces in electrical contact. But non-polar solvents do the reverse. They actually “protect” the metal surfaces from forming new oxides because they inhibit microarcing.

In the chart [2], I list the dielectric constant for a number of solvents, contact cleaners, track cleaners, and the like. To make this chart, I assume a dielectric constant of 3.0 or less constitutes a non-polar solvent for our purposes. I assume a dielectric constant of 10.0 or more means the solvent is polar. Anything in between is semi-polar.

The best solvents for track cleaning are the non-polar ones. The worst ones for track cleaning are the polar solvents! How many of us have used IPA, lacquer thinner, or acetone for track cleaning? Bad, bad! Also notice the "wonder cures" for dirty track are all non-polar! Ah-hah!

The other thing I notice is not all electrical contact cleaners are created the same. CRC Contact Cleaner and Protectorant (do their chemists know something here? – sure sounds like it) is CRC's lowest dielectric constant non-polar product! While CRC 2-26 is often recommended on modeling forums for cleaning, it's actually semi-polar. It's far better than IPA or the like, but the CRC Contact Cleaner and Protectorant is better still. Notice, CRC QD Contact Cleaner is actually worse than IPA. Notice some model railroad track cleaners have lower dielectric constants as well. They're on the right track, no pun intended!

From this list you can see kerosene, WD-40 Contact Cleaner, CRC Contact Cleaner and Protectorant, Deoxit D5, Neverstall, and mineral spirits are all excellent solvents to use for cleaning track and wheels.

Solvents to avoid include: isopropyl alcohol, MEK, acetone, and lacquer thinner.

2. Polar, semi-polar, and non-polar solvents.

Solvent	Dielectric constant
Kerosene	1.8
WD-40 contact cleaner	1.9
CRC contact cleaner & protectant	2.0
DeoxIT D5	2.0
Gasoline	2.0
Neverstall	2.0
Diesel	2.1
Mineral spirits	2.1
Wahl clipper oil	2.1
Turpentine	2.2
Carbon tetrachloride	2.2
WD-40 (regular)	2.4
Graphite (microscopic thin layer)	1.8-3.0
CRC 2-26	4.6
Automatic transmission fluid	4.8
Rail-zip	4.8
Bachmann track cleaner	4.8
Butyl acetate	5.1
Butyl cellosolve	5.3
Ethyl acetate	6.0
Graphite (thick layer)	10.0-15.0
Isopropyl alcohol (IPA)	18.0
Methyl Ethyl Ketone (MEK)	18.9
CRC QD contact cleaner	20.0
Lucas contact cleaner	20.0
Acetone	20.7
Vinegar	24.0
Ethyl alcohol (e.g. vodka, wine)	25.0
Ammonia solution	31.6
Propylene glycol	32.0
Lacquer thinner	33.6
Glycerine	47.0
Hydrogen peroxide	60.0
Water	80.4

Non-polar

Semi-polar

Polar

Here is a link to the whole of the May issue of MRH:

http://mrhpub.com/2019-05-may/download/111.MRH19-05-May2019-P.pdf?utm_source=mrhpub.com&utm_medium=referral&utm_campaign=mrh1905