Methods of Polymer Removal from Metal Filters
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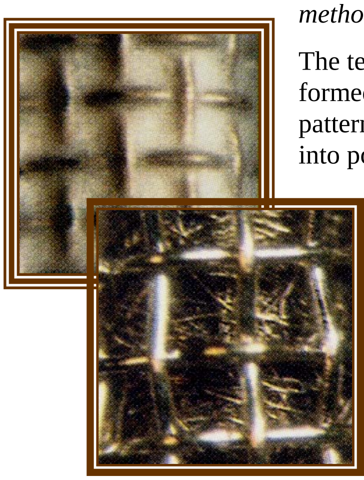
Because metallurgy and construction of equipment and filters used in chemical and polymer processes are specified so that the parts can withstand the pressures, temperatures, and/or corrosiveness of those processes, the parts can be expensive. The high cost of such equipment necessitates its re-use, which creates the need for polymer removal. Methods selected to remove the polymer depend not only on the polymer but also on the part - its configuration and metallurgy. The chemical reactivity/stability of the metal in relation to cleaning chemicals must be considered. If high temperature methods are used, temperature limitations and atmospheric environments become important. Because of the expense and fragileness of parts and filter media, special care must be used in choosing the method of polymer removal.



The term "polymer" refers to a substance formed by linking one or more species of atoms or groupings of atoms together in long sequential patterns usually by covalent bonds. The method and type of linking converts simple molecule(s) into poly-molecular structures that provide various desirable properties. While formulating and producing polymers can be challenging, removing polymers from filters or parts will present a different set of issues. Understanding the chemistry and mechanism of a polymerization reaction can be valuable in determining how to safely remove polymer from the structure.

Since most polymers used in the manufacturing of plastics are not soluble in water or other non-regulated solvents, depolymerization may be required. Depolymerization "unzips" the polymer chain to form smaller units, such as monomer, dimer, etc., which may dissolve in or react with cleaning agents. In other cases, there may not be appropriate solvents or solutions that can be used to remove the polymer or its smaller units. In those cases, high temperature or alternative options may be required.

For example, consider the following general polymerization reactions:

Equation 1: Typical Condensation Reaction:

$$HOOC\text{-}R^1\text{-}COOH + HO\text{-}R^2\text{-}OH \rightarrow [\sim O\text{-}R^1\text{-}OOC\text{-}R^2\text{-}CO\sim]_n + (n+1)\ H_2O$$

Equation 2: Typical Addition Reaction:

$$n\ CH_2 = CH_2 \rightarrow [\sim CHR^1 - CHR^2 \sim]_n$$

where"R" represents an organic or an organic/ inorganic group

In polymer chains such as Equation 1, the chain will generally undergo hydrolysis reactions, whereby, the polymer chain may be attacked by hydroxylated compounds at the acyl or carbonyl carbon positions. Glycols are among organic solvents commonly used for such polymers. In some cases depending on the strength of the bonds around the carbonyl group(s), steam or aqueous solutions of acids and bases may be used. DEECOM®, an alternative technology to chemical methods, uses mechanical decompressive energy along with hydrolysis to remove the polymer. The degree of hydrolysis during the DEECOM® process is dependent on operating parameters. Examples are polyester, nylon-6, and polycarbonate.

For polymers represented by Equation 2, solvents regulated by the EPA, such as aromatic or halogenated solvents, may be required. To avoid storing and using these solvents, burnout processes are typically used. Vacuum Thermal Cleaning Systems, such as VacuClean®, and Convection Ovens, such as Steelman & Pollution Control Products, provide differing methods of oxygen control as needed for the safety of the type of part or filter being processed. Examples are polyethylene, polystyrene, and polytetrafluoroenthane.

The method and level of difficulty in removing polymers from metal filter media can be affected by

- types and locations of functional groups,
- types and locations of alkyl groups, and
- polymer chain configuration (i.e., linear, branching, cross-linking, etc).

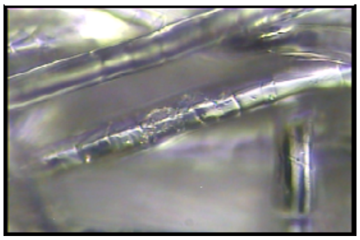
Because many polymers are composed of various polymer types, combinations of removal methods may be necessary. A major point to consider is that the method of polymer removal ***must not be damaging*** to the filter or part.

Since the method of polymer removal is dependent on characteristics of both the filter media metallurgy/construction and the polymer, before developing a method of polymer removal, several things must be considered.

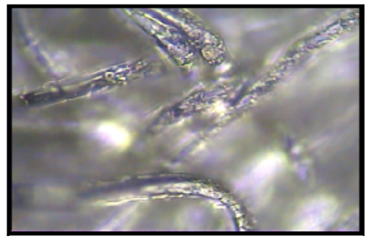
1. Characteristics of the metal and type of filter or part:

- Composition: The material of construction of the part, i.e., type of stainless steel, exotic alloy, or carbon steel, will determine the chemicals that can be used to clean the part.
- Temperature Limitations: Some metals have temperature limitations which if exceeded can cause irreversible effects on the metal, such as sensitization, changes in hardness, and maybe even melting.

Good Media



Media Damage from Burning



2. Characteristics of the polymer:

- Physical Properties: Solubility, melting parameters, heat flow characteristics, response to ultrasonics, brushing, and other physical forms of removal.
- Chemical Properties: Chemical reactivity, response to heat under atmospheric vs vacuum conditions.

It is important to note that in terms depolymerization processes, the specific filter or part and polymer must be individually considered. While the following table provides comparisons of various depolymerization processes, the results are qualitative, not quantitative, and are based on general and not specific process examples.

Table: Comparisons for Depolymerization Methods

	Thermal Oxidation can occur	Sensitization can occur	Possible chemical attack	Temps > 430°C are possible	Removes carbon, & degraded polymer	Removes inorganic particulate	Post-Cleaning Needs
Convection Ovens	Yes	Yes	No	Yes	Yes	No	Medium
Vacuum Ovens w/oxidation	Not Likely	Yes	No	Yes	Yes	No	Low/ Medium
Salt Baths	Yes	Yes	Yes	Yes	Yes	Some	High
Solvents	No	No	No	No	No	Some	High
DEECOM®	No	No	No	No	Yes	Yes	Low/ Medium

In summary, to recycle or reuse expensive metal filters, the first step is to remove the polymer or major contaminant. How this is done can affect the life and overall performance of the filter. The major factors in selecting the depolymerization process are the filters and the polymer. To remove the polymer safely and effectively, it is necessary to:

- ***understand*** the chemistry of the polymer being removed and the construction and constraints of the filter media,
- ***develop*** a process that removes the polymer without damaging the filter media, and
- ***control*** the process conditions during polymer removal.

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Bio

Sue L. Reynolds has been with Carolina Filters since 1990. During that time, she has worked in all aspects of the cleaning operation with major duties involving process development, procedures, and working with customers in Technical Sales.

She has a BA in Chemistry from Winthrop University and a Masters in Mathematics from the University of South Carolina. In the past, she worked in the education field teaching chemistry, physics, and various levels of mathematics in private & public schools, at the University of South Carolina, and at the Carolina Technical College.

She is affiliated with numerous scientific and filtration organizations. She has published several papers that cover various aspects of cleaning.