PALL CORPORATION

Achieve Functional, High-Quality Plant Proteins with Pall Purification Solutions

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According to Food Dive, the numbers show the trend for plant-based proteins growing. Investment firm UBS projects growth to increase from $4.6 billion in 2018 to $85 billion by 2030 and a recent study from DuPont Nutrition and Health found that 52% of US consumers are eating more plant-based foods because they believe it makes them healthier.

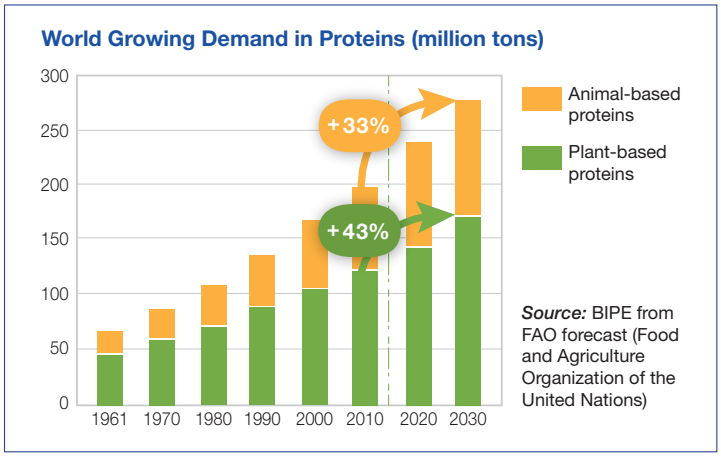

Figure 1: World growing demand in proteins

Within the plant-based protein world, protein ingredients represent high added value to food products due to their functional properties.

In order to preserve protein's natural functionalities, the production process must minimize potential denaturation effects induced by thermal, chemical or mechanical stress and prevent carrying natural contamination such as suspended solids, bioburden, fat and antinutritional factors.

The current wet purification process usually includes at least one step of thermal and/or chemical precipitation at iso-electric point to settle the globulins (also known as larger proteins) further recovered by centrifugation. This process creates partial protein denaturation (potential structure modification) that may negatively impact solubilization of final protein powder and other properties like gelation, foaming, water retention, among others.

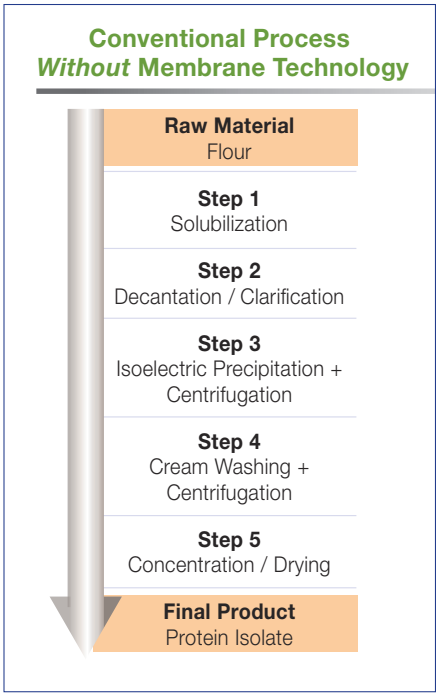

Figure 2: Traditional process schematic

Key Takeaways

In wet purification process, crossflow filtration technology:

- Preserves plant proteins natural quality and functionalities
- Removes suspended solids, fat and bioburden (including spores)
- Delivers concentrates with up to 95% proteins on Total Solids
- Produces added value products from side streams

As an alternative to standard precipitation and centrifuge separators, crossflow microfiltration can purify the raw feed to produce a very clean solution of native proteins.

This stream can be further fractionated and/or purified with other membranes (UF/NF/RO) and/or chromatography.

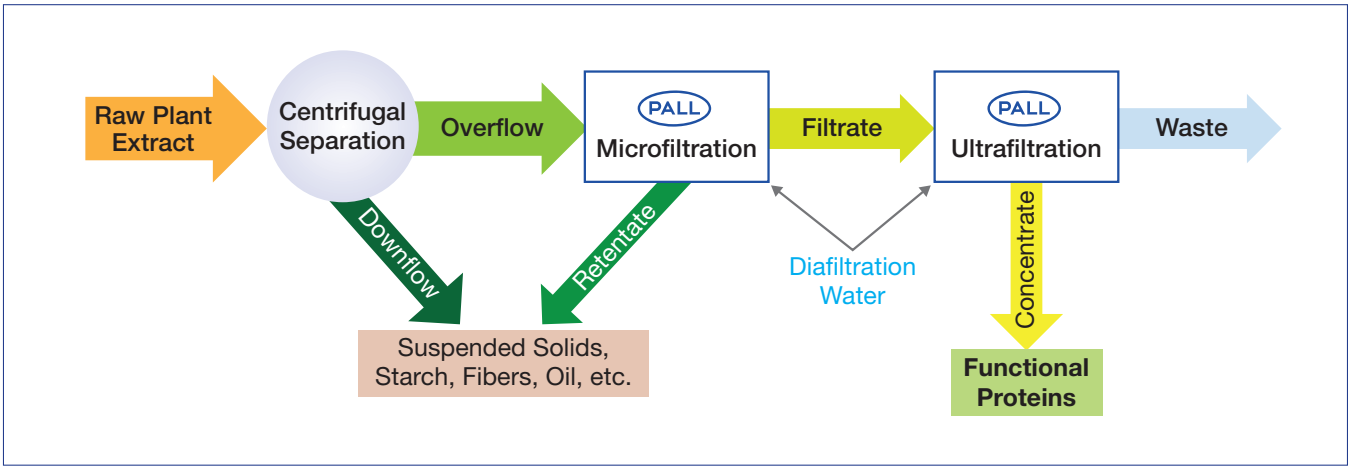

Figure 3: Membrane based process to produce functional proteins

In the traditional process, a small fraction of the precipitated globulins and the bulk of soluble proteins, typically the albumins, generally are lost in the centrifuge overflow. This stream can be filtered to recover unsettled globulin fines that could be mixed back with centrifuge downflow leading to globulin yield increase. The permeate produced at this step is a clean solution of native dissolved albumins. Further concentration and purification of this solution can lead to valuable products with interesting properties, equivalent to whey proteins from dairy processing.

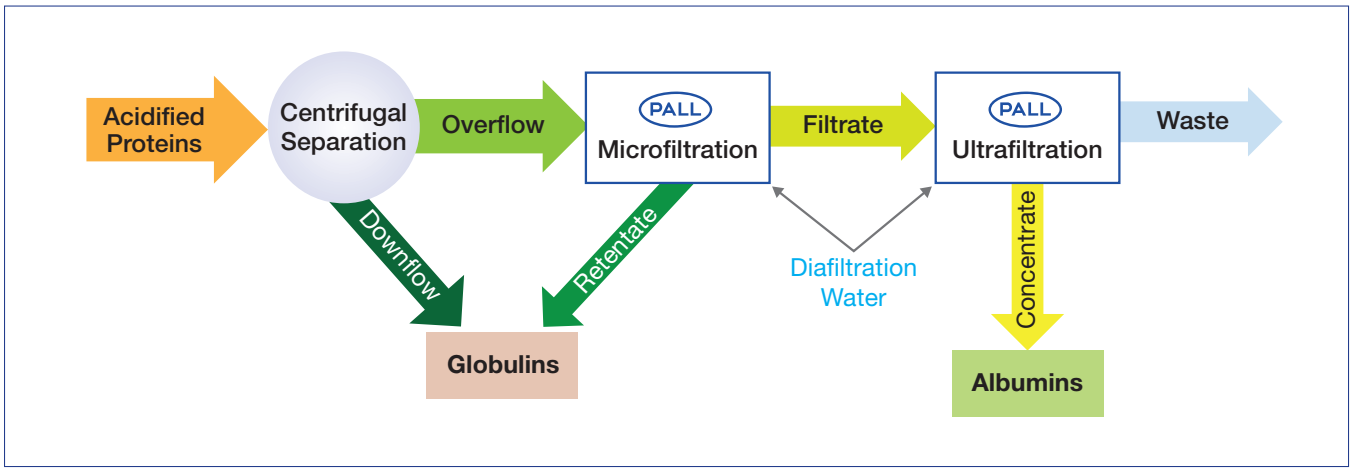

Figure 4: Membrane based process schematic to increase precipitated globulin yield and produce native albumins concentrate

The dairy industry leverages crossflow microfiltration and has for decades. In dairy production, crossflow microfiltration purifies the milk by removing bioburden and residual fat and fractionate the milk by separating casein from whey proteins, while maintaining native properties of each type of proteins.

With membrane filtration, the dairy industry continuously pushes further milk cracking processes to create new products and added value ingredients. Crossflow filtration is transferrable across markets, and as such, food manufacturers producing plant-based proteins can also leverage this information and technologies to improve their current processes

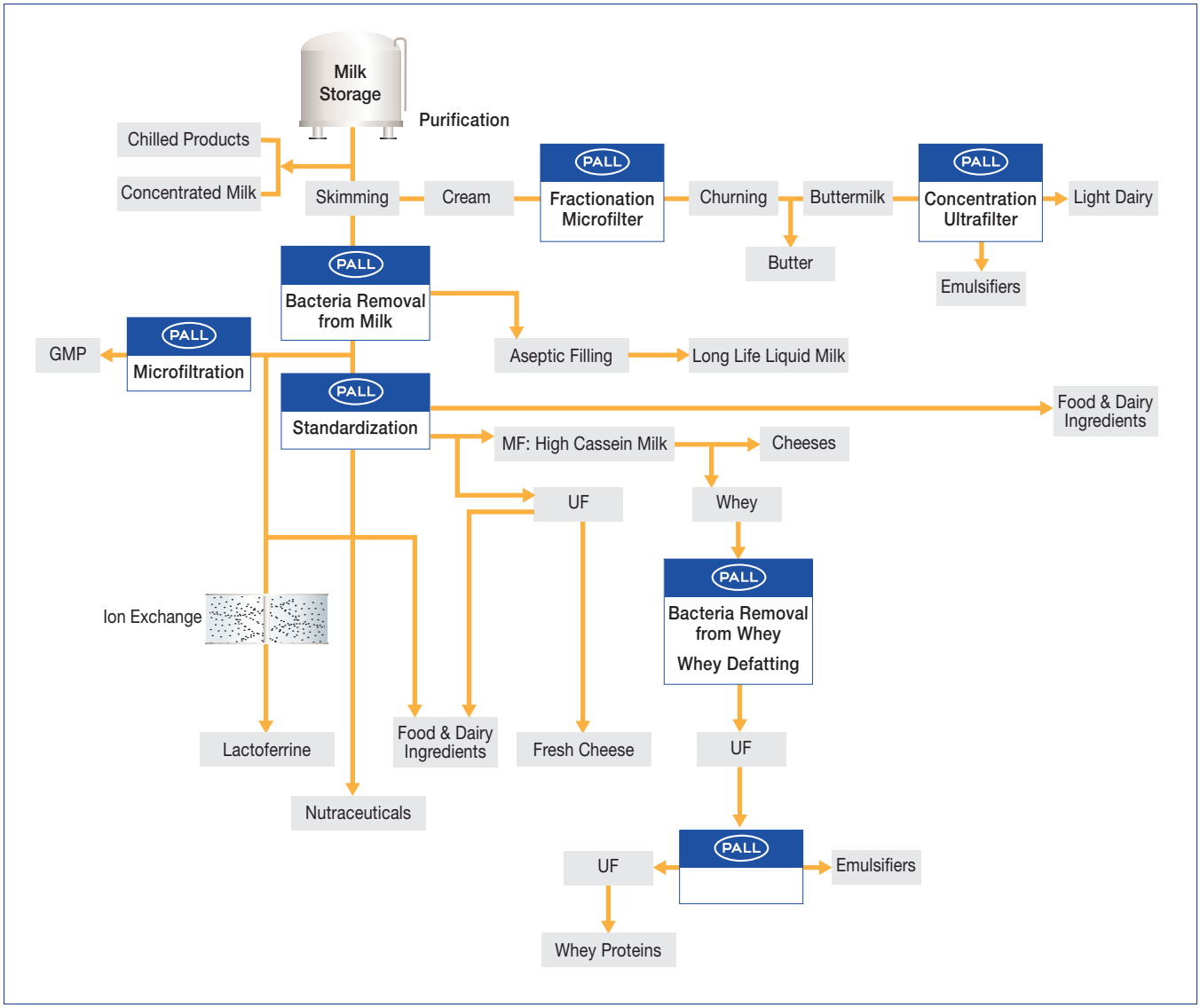

Figure 5: Membrane based dairy process examples

Some manufacturers already use crossflow membrane solutions to purify other types of protein, such as:

- animal-based (*e.g.,* gelatin, blood or blood serum, fish hydrolysates)
- plant-based (*e.g.,* proteins from wheat, rice, barley, potato, leaves)
- produced by microorganisms (*e.g.,* enzymes, proteins, algae extracts)

Crossflow filtration is a physical barrier that achieves high purification yield without filter aids, and chemical or thermal treatment. Among other advantages, this technology allows valorizing both the concentrate and filtrate streams at each filtration step.

The microfiltration filtrate (also called permeate) is a crystal-clear solution of soluble proteins, ready for downstream purification and concentration steps.

The ultrafiltration protein concentrate has high added value, thanks to its exceptional purity and full functionality.

Additionally, with the same filtration equipment, concentrates can be “washed” or purified through a process called Diafiltration to improve the recovery yield in case of microfiltration or to increase the purity (proteins over total dry solids ratio) in case of ultrafiltration.

The purified proteins with up to 95% proteins on total solids can be concentrated up to 30% dry solids then dehydrated for example into low temperature spray dryers. Thanks to native functionalities, the final protein powder easily solubilizes in water.

Crossflow filtration systems are fully enclosed and automatized – meaning they are regularly cleaned and sanitized in place (with minimum manpower), thus operating at suitable temperatures to prevent any thermal denaturation of the product while maximizing separation performances.

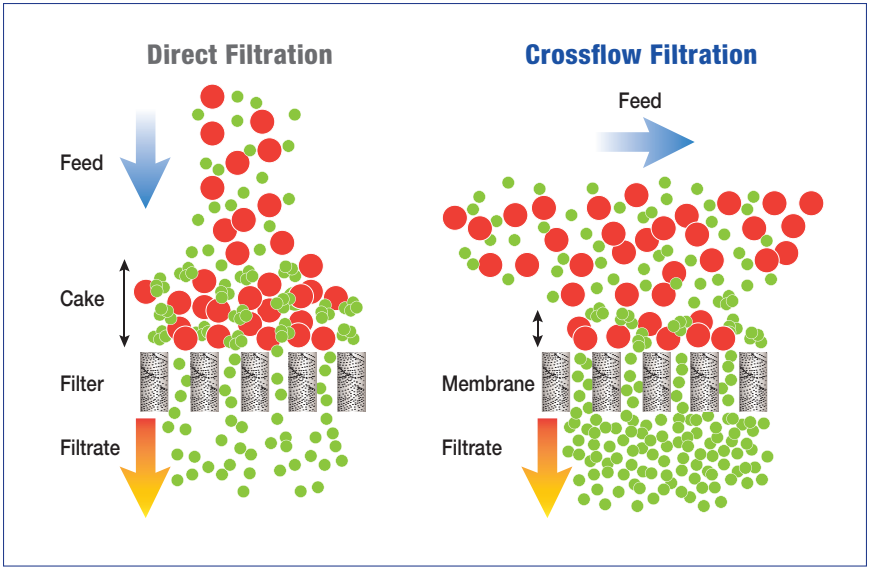

Figure 6: Crossflow filtration versus direct filtration

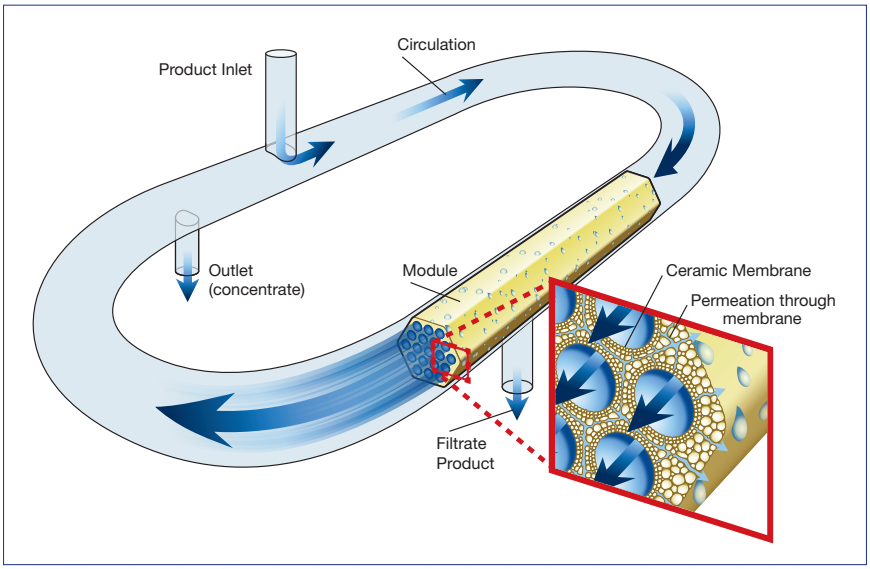

Figure 6.1: Crossflow filtration flow path

Their modular design allows to process of any feed flow rates, generally at constant throughput, possibly in full continuous mode (24/7) but also into sequencing batch processes.

Membranes life time extends over years of continuous operation with consistent separation performances and capacity.

Figure 7: Examples of Membralox products

Figure 8: Example of Membralox system

Pall offers a comprehensive range of membranes grades (separately or in combination) to cover process needs:

- **"Open" Microfiltration:** The removal of undissolved solids, including microbial contamination and oil/fat to produce a diluted "clean" protein solution
- **"Tight" Microfiltration:** This type of filtration fractionates proteins according to their size and thus separate globulins from albumins, both products having specific properties and high added value
- **"Open" Ultrafiltration:** This process concentrates more specifically the large proteins
- **"Tight" Ultrafiltration:** This type of filtration concentrates all proteins, including the smallest ones

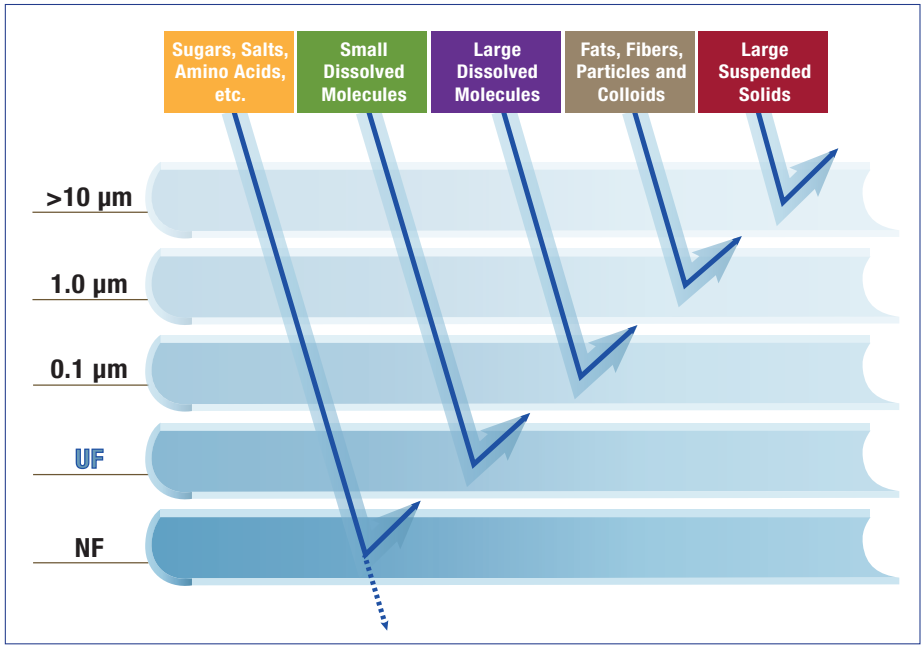

Figure 9: Separation charts

Summary

Crossflow filtration contributes to the production of protein fractions with:

- Native quality and functionalities,
- High purity (up to 95% proteins on total solids)
- Very low microbial/spore counts,
- Very low-fat content,
- No suspended solids.

To produce plant-based proteins for the food market, manufacturing facilities need to take care of the quality of any additives and utilities used in the process, including but not limited to incoming water, air and/or process gases and others liquid additives such as enzymes.

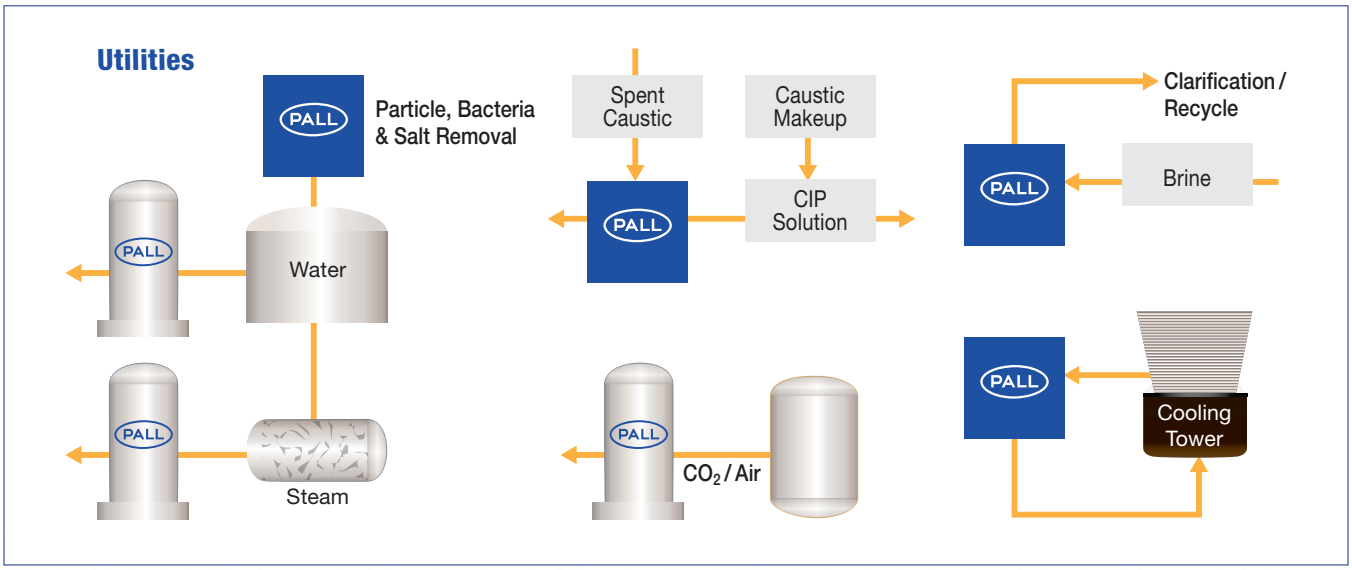

Figure 10: Pall solutions for utilities filtration

For each of these streams, Pall offers Food Contact Compliant purification solutions based on direct flow filtration with cartridges membrane, depth filter media or hollow fiber membranes.

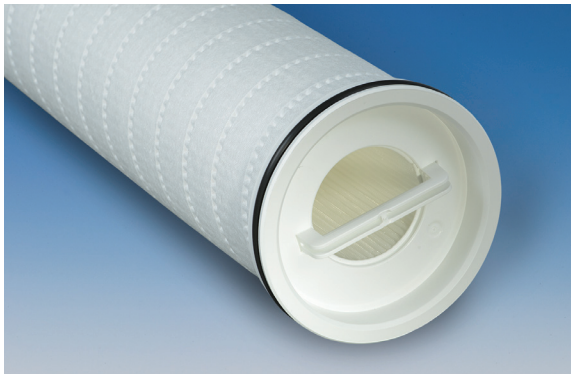

Figure 11: Examples of Pall direct flow filters

Our Pall Scientific Laboratory Service (SLS) team works with customer to develop the best technical and economical solution for each of the required purifications applications.

Contact your Pall representative to learn more.

Figure 12: Example of Hollow Fiber system for water filtration

About Pall

Pall Corporation provides critical filtration, separation and purification solutions to meet the demanding needs of a broad spectrum of life sciences and industrial customers around the globe.

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