

# Clarification Solutions for Pre-treated Feed Streams

## Clarisolve® Depth Filters pDADMAC Polymer

The current evolution to high cell density and high-product titer monoclonal antibody cell cultures is placing a larger burden on traditional downstream clarification and purification operations. To alleviate this bottleneck, various types of pre-treatment are being employed to make the clarification process more efficient.

Polycationic polymer modified poly (diallyldimethylammonium chloride) [pDADMAC] is a very effective flocculation polymer that can be used as a pre-treatment solution when used in combination with our Clarisolve® depth filters. The Clarisolve® depth filter is a primary clarification tool with a gradient density structure specifically designed to the particle size distributions of pre-treated feed streams. With improved volumetric capacity and reduced turbidity over currently available depth filters, the clarification step of pre-treated feeds can be processed in a significantly reduced footprint.

Together, the pDADMAC polymer, and Clarisolve® depth filters provide an effective solution for harvesting high cell density cultures that can be easily incorporated into current clarification platforms.

### Benefits of This Pre-treatment Platform

- Provides an efficient way to clarify high-density pre-treated feed streams
- Enables processing of pre-treated feeds in a significantly reduced footprint with reduced flushing requirements
- Eliminates the need for centrifugation and enables implementation of a single-use clarification train
- Fully scalable from bench to process scale in a modular, self-contained pod format



### Pre-treatment Methodologies

#### Effective methods to clarify high-density feed streams

Pre-treatment is accomplished either through the reduction in pH of the feed stream (acid precipitation) or through the addition of cationic polymers including pDADMAC, PEI, and chitosan. These methods result in aggregation of smaller particles into larger agglomerates thus reducing small particles which are difficult to centrifuge and can plug downstream filters (**Figure 1**). Flocculation technologies can also potentially reduce soluble impurities such as DNA and HCP, reducing the burden on downstream processing.

## Polymer Product Information

pDADMAC is a water-soluble polymer widely used as a flocculant in waste water treatment. Commercially available solutions of this polymer contain residual monomer and sodium chloride in significant concentrations and may come with high bioburden. We have developed a purification method that reduces the content of low molecular weight polymer and the concentration of the monomer to less than 0.1% and eliminates sodium chloride at the same time.

A 0.2  $\mu\text{m}$  filtration step is performed to reduce the microbial count to less than 10 CFU/mL. The molecular weight distributions of both polymers are shown in (Figure 2) .

## Use of Polymers in Flocculation

For pDADMAC polymer, the best flocculation results are when used in a concentration between 0.01% and 0.05%.

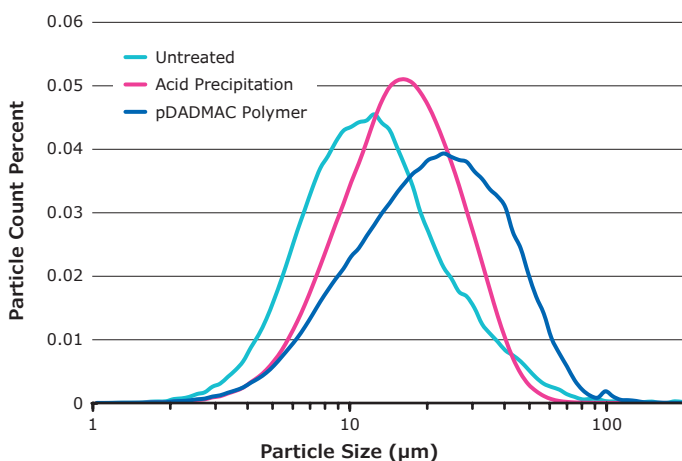
## In-Process Polymer Removal and Safety

Studies have shown that the residual concentration of the pDADMAC polymer is below 1 ppm following the downstream purification train. No cytotoxicity or acute systemic toxicity was observed at this concentration in toxicological studies, nor have irritant (intracutaneous injection) or haemolytic effects been found.

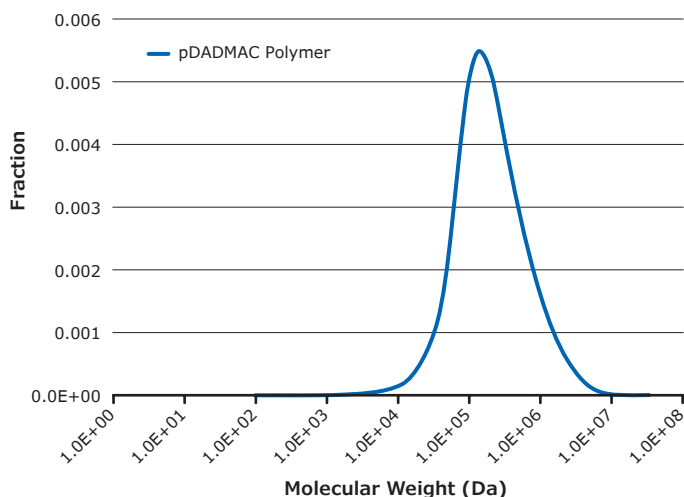
## Quantitation of Residual Polymers

We provide a service to quantitate the residual level of pDADMAC polymer in sample matrices from a cell culture harvest and clarification before and after the purification steps.

A report is issued including a description of samples submitted, quantitation of the polymer residuals and a chromatogram overlay including the standard. Final reports are issued electronically in a PDF format.



**Figure 1.** Particle size distribution of various pre-treatment methodologies



**Figure 2.** Molecular weight distributions of pDADMAC polymer after purification

## Clarisolve® Depth Filters

### Successful in a variety of mAb, vaccine, and microbial lysate feed streams

With pre-treatment methodologies, the shift in particle size distribution of the flocculated feed stream may result in inefficient conventional centrifugation and depth filtration. This can lead to large depth filtration installations which may be difficult to fit into existing facilities or new facilities where footprint is limited. Clarisolve® depth filters have been optimized to match the particle size distribution of typical pre-treated feeds, resulting in improved filtration performance not seen with traditional primary clarification depth filters.

### Filtration Performance

Success with multiple monoclonal antibody (mAb) cell culture streams of varying cell densities and viabilities, including high-density cell cultures with various flocculation techniques has been demonstrated with this robust clarification technology. Clarisolve® depth filters have also been used successfully for microcarrier removal, lysate clarification, and in viral vaccine processes.

### Flushing

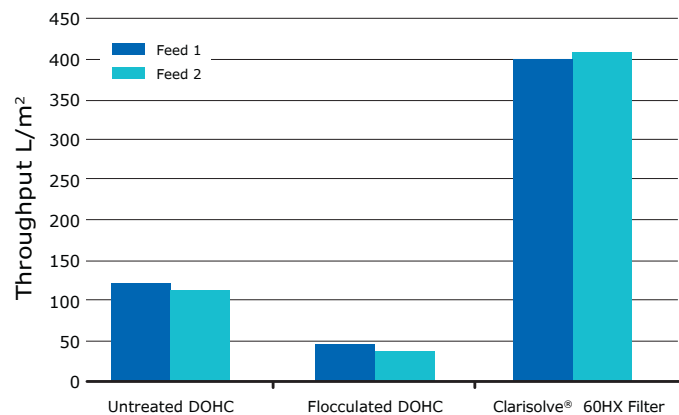
20MS, 40MS, and 60HX media grades can be flushed at flux rates ranging from 100 LMH to 600 LMH, depending on process and equipment capabilities. The 60HX media grade has the lowest flushing requirement among the family of Clarisolve® filter media grades.

### Device Wetting and Hold Up Volumes

All media grades exhibit excellent wetting characteristics at flush rates from 100 LMH to 600 LMH. Additionally, lower hold up volumes post blow down allow for greater product recovery over conventional depth filters.

## Selection Guide

Pre-treatment Option	Clarisolve® Depth Filter
<b>Acid Precipitation</b>	
Particle size of 10–20 µm	20MS
<b>Cationic Polymer Flocculation</b>	
Particle size of 30–40 µm	40MS
Particle size of 50–60 µm	60HX



**Figure 3.** Filtration performance of 2 mAb feed streams highlighting the improvement in depth filter capacity with pre-treatment and Clarisolve® depth filters.

## Clarisolve® Depth Filters are supported by the Emprove® Program- The Smart Way to Master Compliance and Control.

Complementing our product portfolio, the Emprove® Program provides convenient access to reliable technical, regulatory and supply information in Emprove® Dossiers to support your risk assessment continuum. A subscription to our Emprove® Suite can help you stay current: In addition to accessing the Emprove® Dossiers, you can also receive notification updates to document changes, as well as generate metrics and reports. For more information, please visit: <https://sigmaaldrich.com/emprove>.

### Bulk Packaging

To improve sustainability of the packaging and shipping of filter products, we have developed a bulk pack solution for several grades of Clarisolve® Process-scale Pod filters with the aim to optimize transport and reception processes as well as to reduce waste. Bulk packaging configuration includes 24 Pods in 3 boxes with 8 Pods per layer on 1 pallet.

### The key benefits are:

- 43% average reduction in corrugated packaging materials per product
- 25% decrease in the number of pallets further reducing energy use and emissions
- 75% reduction in operator time to open and manage the product and packaging

## Clarisolve® Depth Filter Format Specifications

	µPod® Device Format		Lab Scale		Process Scale		
Surface Area	23 cm²		0.014 m²	0.027 m²	0.11 m²	0.33 m²	0.55 m²
Materials of Construction							
Filter Media	Polypropylene and cellulosic media with an inorganic filter aid (60HX contains polypropylene media only)						
Housing	Glass Filled Polypropylene						
Adapters	N/A		N/A		Glass Filled Polypropylene		
Gaskets and Plugs	N/A		N/A		Thermo plastic elastomer (TPE)		
Inlet, Vent and Outlet Connections	Female Luer		1/4 in hose Barb		Flat Seal		
Pod Dimensions							
Length:	3.57 in (9.07 cm)		8.5 in (22 cm)		24.2 in (62 cm)		
Height:	2.75 in (6.99 cm)		5.3 in (14 cm)		12.5 in (32 cm)		
Thickness (20MS and 40MS):	1.96 in (4.98 cm)		2.9 in (7.40 cm)	3.7 in (9.40 cm)	2.0 in (5.08 cm)	4.4 in (11.18 cm)	6.8 in (17.27 cm)
Thickness (60HX):	1.81 in. (4.60 cm)						
Maximum Operating Pressure	50 psig (3.5 bar) at ≤40 °C		30 psig (2.1 bar) at ≤37 °C		50 psig (3.5 bar) at ≤25 °C 15 psig (1.0 bar) at ≤80 °C		
Maximum Differential Pressure							
Forward:	30 psid (2.1 bar) at ≤40 °C		30 psid (2.1 bar) at ≤37 °C		30 psid (2.1 bar) at ≤25 °C		
Reverse:	15 psid (1.0 bar) at ≤40 °C		30 psid (2.1 bar) at ≤37 °C		30 psid (2.1 bar) at ≤25 °C		
Sterilization	2 autoclave cycles of 60 minutes at 123 °C				1 autoclave cycle of 60 minutes at 123 °C		
Indirect Food Additive	All component materials meet the FDA indirect food requirements cited in 21 CFR 177-182						
Toxicity	All component materials comply with the requirements of USP <88> biological reactivity tests for class VI plastics						
Bacterial Endotoxins	An aqueous extraction contained less than 0.25 EU/mL as determined using the Limulus Amebocyte Lysate (LAL) test technique (on filter media only), meeting requirements of USP <85>, EP 2.6.14 and JP 4.01.						
Pressure Equipment Directive 2014/68/EU	Devices and associated holders are designed and manufactured in accordance with the sound engineering practices (SEP) cited in Article 4(3) of 2014/68/EU						

## Ordering Information

Description	Qty/Pk	Cat. No.
<b>Clarisolve® Depth Filters in µPod® Device Format</b>		<b>Surface Area</b>
		<b>23 cm²</b>
20MS Media	3	CS20MS01L3
40MS Media	3	CS40MS01L3
60HX Media	3	CS60HX01L3

<b>µPod® Filter Accessories</b>		
µPod® Tubing Kit	1	MTUBEKITL1
Gauge 0–60 psi and Connection Fittings	1	XXPXLGAGE

<b>Clarisolve® Lab-Scale Pod Depth Filters</b>		<b>Surface Area</b>	
		<b>0.014 m²</b>	<b>0.027 m²</b>
20MS Media	1	CS20MS01H1	CS20MS02H1
40MS Media	1	CS40MS01H1	CS40MS02H1
60HX Media	1	CS60HX01H1	CS60HX02H1

<b>Clarisolve® Process-Scale Pod Depth Filters</b>		<b>Surface Area</b>		
		<b>0.11 m²</b>	<b>0.33 m²</b>	<b>0.55 m²</b>
20MS Media	1	CS20MS01F1-X	CS20MS03F1-X	CS20MS05F1-X
40MS Media	1	CS40MS01F1-X	CS40MS03F1-X	CS40MS05F1-X
60HX Media	1	CS60HX01F1-X	CS60HX03F1-X	CS60HX05F1-X

<b>Clarisolve® Process-Scale Pod Depth Filters in Bulk Packaging Format</b>		<b>Surface Area</b>	
		<b>0.55 m²</b>	
20MS Media	24	CS20MS05FS24	
40MS Media	24	CS40MS05FS24	
60HX Media	24	CS60HX05FS24	

<b>Disposable Adapter Kit</b>	<b>Qty/Pk</b>	<b>Cat. No.</b>
3 through adapters, 3 blind adapters	1	MP0DADAPT
6 through adapters, required if using MP0DDIVERTR	1	MP0DADPTF

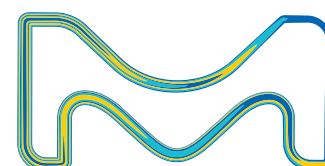
<b>Flocculation Polymer</b>	<b>Qty/Pk</b>	<b>Cat. No.</b>
	100 mL	1.37069.0100
pDADMAC solution 10% flocculation polymer	1 L	1.37069.1000
	10 L	1.37069.9010

<b>BioReliance® Service</b>	
Quantitation of Residual pDADMAC	VSPDADMAC

**Note:** Pod filters require the use of flow adaptors which are sold separately (MP0DADAPT or MP0DADPTF). See the Millistak+® Pod disposable depth filter hardware data sheet (DS3388EN00) for information on Pod filter holders.

A retrofit kit may be required in order to accommodate the Clarisolve® depth filters in the Pod pilot and process-scale holders. Please contact your local sales representative for details.

Merck KGaA  
Frankfurter Strasse 250  
64293 Darmstadt, Germany



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