

Wine filtration and filterability – a review and what's new

When it comes to filtering the good stuff from the bad – whether it's wine or information about wine – Paul K. Bowyer, Greg Edwards and Amelia Eyre know more about it than most people.

AT A GLANCE:

- Many forms of filtration are available to winemakers, each with advantages or disadvantages, and can include earth, pads, lenticulars, tangential flow (cross-flow) and membranes.
- Absolute-rated filtration media are those for which an efficiency of higher than 99.98 per cent is stated, which corresponds to a beta ratio of 5000:1 or better.
- Contrary to popular belief, cross-flow filtration is not a sterile process, since it cannot be integrity tested.

THE PURPOSE OF filtration is to clarify or purify any product to meet a given specification for consumer acceptance in terms of microbial and/or physical stability.

In general terms, filters fall into two main categories – depth filtration and membrane filtration.

The purpose of depth filtration is to retain the primary particulate load,

while membrane filtration is used to provide a defined barrier.

Many forms of filtration are available to the winemaker, each with its own advantages or disadvantages, and these can include earth, pads, lenticulars, tangential flow (cross-flow) and membranes.

Diatomaceous earth (DE) is inexpensive but is incapable of very fine filtration and is hazardous, with a strong impact on wine flavour and colour. Most pads are a blend of cellulose and DE (although some pure cellulose pads are available), are relatively inexpensive, yet contain DE, and so some of the problems associated with DE flow into pad usage, such as disposal and organoleptic impact.

Lenticular filters are reformatted pads. Tangential flow (cross-flow) filtration is a system which can remove particulate, is typically automated, and is best suited to cellar filtration. Contrary to popular belief, cross-flow filtration is not a sterile process, since it cannot be integrity tested.

Although the utility of cross-flow filtration is high, it is not a replacement for lenticular filters per se. Membranes are typically absolute rate (usually

expressed as a Log Reduction Value [LRV]), meaning their efficiency is a form of barrier filtration, typically being made from nylon or polyethersulfone (PES).

They are challenged with microorganisms to ensure required levels of organism removal are met. Membranes are typically absolute rated, meaning their filtration efficiency is measurable and stated.

Absolute-rated filtration media are those for which an efficiency of higher than 99.98 per cent is stated, which corresponds to a beta ratio (the ratio of particulates larger than the stated porosity retained on the medium relative to the those that pass through) of 5000:1 or better.

NEW DEPTH MEDIA

The most recent development in depth media for wine filtration is the 100 per cent cellulose materials from E. Begerow of Germany (Figure 1; Bowyer, 2012).

The new medium possesses several advantages over standard depth media, such as increased physical strength, increased service life, minimal drip loss, less water required to condition, the ability to steam-sterilise, and no citric

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Since there is no DE in the medium there is minimal possibility of organoleptic impact on the filtrate.

In other areas of food production – for example olive oil filtration – this has been shown to be of great significance, and an additionally an increase of approximately 100 per cent in terms of throughput (Thomas, 2012) compared with a standard medium was recently observed.

Perhaps the greatest advantage of the pure cellulose medium, however, is in terms of colour adsorption.

The absence of DE substantially reduces pigment adsorption to the medium, which noticeably improves wine visual quality parameters.

This is especially important for wines containing less pigmentation, or where colour (hue) and colour density are deemed important, as they are for most red and rosé wines.

NEW MEMBRANE MEDIA

Nylon is a versatile polymer, but not necessarily the best in terms of wine filtration applications, even though it is in widespread use.

The membranes are symmetrical, meaning they are of approximately

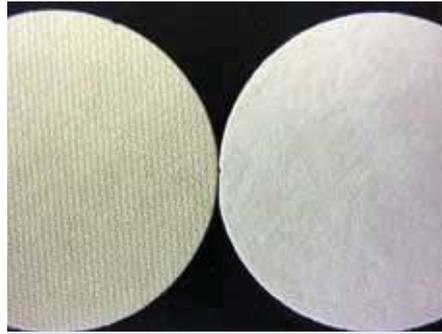


Figure 1: Standard (left) and cellulose (right) depth media. The beige colouration of the standard medium is due to the presence of diatomaceous earth, which adsorbs colour.

uniform density from entry to exit of the medium.

Nylon in its various forms (see Figure 2) is formed from the reaction of amines and carboxylic acids, the result being a peptide bond such as those found in proteins.

In the peptide bond the secondary amino nitrogen is bonded to a hydrogen atom, and due to the difference in electronegativity (Bowyer, 2003) between N and H, bond polarisation occurs, generating a partial positive charge on the hydrogen atom.

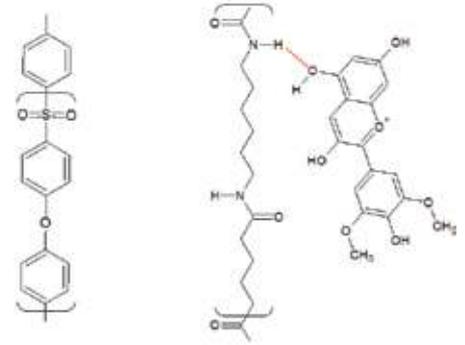


Figure 2: Chemical structures of polyethersulfone (left) and nylon (right). The nylon structure indicates potential hydrogen bonding to an anthocyanin via the amide hydrogen atom.

This serves as an anchor point for any localisations of negative charge on other molecules as they pass through or come into surface contact with the medium, increasing retention and adsorption of these materials through hydrogen bonding.

This is of particular concern in rosé and red wines, as colour is a key quality parameter (for example, see Francis, 1995), and it is easy to understand nylon



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membranes will be inherently colour-retentive.

Polyethersulfone (PES) is a newer membrane medium becoming more widely accepted due largely to the pioneering efforts of Parker-domnick hunter, which has advocated PES for wine filtration applications since 2000 and does not offer a nylon wine filtration membrane.

PES offers significant advantages in terms of colour retention, physical

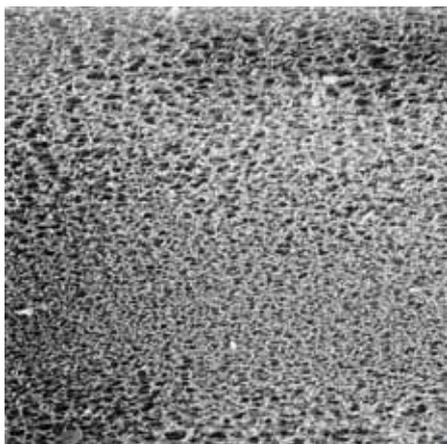


Figure 3: Cross-section of a PES membrane illustrating the asymmetric nature of the medium. The tighter central region provides the microbial retention capacity, whilst the coarser outer regions provide loading capacity and support structure. Image courtesy of Parker-domnick hunter.

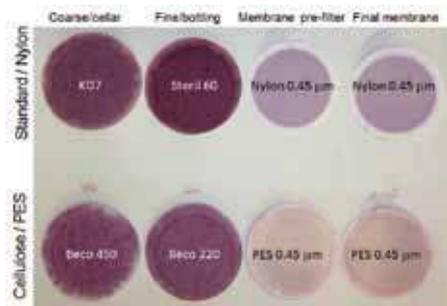


Figure 4: Spent filtration media after passing 100 mL 2012 Malbec in sequence from left to right as pictured for each train.

robustness and flow rates compared with nylon.

The PES polymer (Figure 2) critically lacks the ability to hydrogen bond, leading to its almost zero colour adsorption.

PES is typically cast in an asymmetric manner (Figure 3), meaning the membrane is rather like a thin depth medium, which generates significant benefits in terms of flow rate and loading capacity, both of which are higher than nylon.

RELATIVE PERFORMANCES OF MEDIA TYPES

Wine (2012 Malbec) was passed in sequence through a series of filtration media, commencing with coarse grade pad, then tight pad, followed by two 0.45µm membrane discs.

Commonly, 0.65µm membrane pre-filters would be used at bottling, however in this study a 0.45µm disc was used in sequence to illustrate colour binding, as opposed to particulate retention, was taking place.

The used media are pictured in Figure 4, and the colour binding data are given

in Table 1. A graphical representation of these data is provided in Figure 5.

The same methodology was applied to a 2012 rosé, and the data are presented in Table 2 and Figures 6 and 7.

COLLOIDAL LOADING

We have previously demonstrated NTU is a poor indicator of wine colloidal loading and capacity to foul filtration media (Bowyer, Edwards and Eyre, 2012), and investigated the potential impact of CMC.

In order to further evaluate the influence of colloidal loading to a wine in terms of impact on wine filterability index (FI), investigations were made with concentrate and exogenous tannin. A 2011 Shiraz (NTU 0.56, FI = 7.6) was treated with additions of concentrate (equivalent to 4 g/L residual sugar) and exogenous tannin (25 ppm), the sample left overnight and then tested. The wine returned values of NTU = 1.1 and FI = Fail (> 1000). FI data recorded for the two samples, pre- and post-addition of tannin and concentrate, are given in Figure 8.

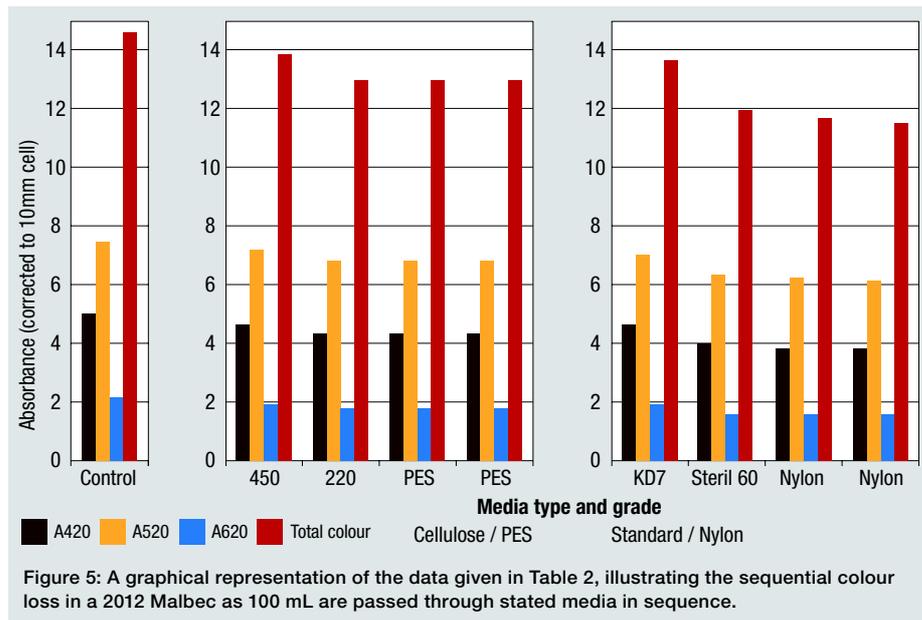


Figure 5: A graphical representation of the data given in Table 2, illustrating the sequential colour loss in a 2012 Malbec as 100 mL are passed through stated media in sequence.

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Table 1: Colour binding results in the model cellar/bottling train for a 2012 Malbec (100 mL) passed sequentially through 47mm discs of specified medium.

	Sample	A420	A520	A620	Total colour	Δ	Colour loss %
Cellulose/ PES	Control (no filtration)	5.00	7.45	2.15	14.60	-	-
	Becopad 450	4.65	7.25	1.95	13.85	0.75	
	Becopad 220	4.35	6.85	1.80	13.00	0.85	
	Bevpor PES 0.45µm	4.35	6.85	1.80	13.00	0.00	
	Bevpor PES 0.45µm	4.35	6.85	1.80	13.00	0.00	11.0%
Cellulose/ PES	Beco KD7	4.65	7.05	1.95	13.65	0.95	
	Beco Steril 60	4.00	6.35	1.60	11.95	1.70	
	Nylon 0.45µm	3.85	6.25	1.55	11.65	0.30	
	Nylon 0.45µm	3.80	6.20	1.55	11.55	0.10	17.5%

Table 2: Colour binding results in the model cellar/bottling train for a 2012 rosé (100 mL) passed sequentially through 47mm discs of specified medium.

	Sample	A420	A520	A620	Total colour	Δ	Colour loss (%)
Cellulose/ PES	Control (no filtration)	1.44	1.67	0.02	3.12	-	-
	Becopad 450	1.24	1.51	0.00	2.75	0.37	
	Becopad 220	1.12	1.37	0.00	2.48	0.27	
	Bevpor PES 0.45µm	1.11	1.34	0.00	2.45	0.03	
	Bevpor PES 0.45µm	1.10	1.34	0.00	2.44	0.02	21.8
Cellulose/ PES	Beco KD7	1.10	1.27	0.00	2.36	0.76	
	Beco Steril 60	0.93	1.08	0.00	2.01	0.36	
	Nylon 0.45µm	0.86	0.98	0.00	1.83	0.18	
	Nylon 0.45µm	0.76	0.91	0.00	1.67	0.16	46.5



Figure 6: Spent filtration medium after passing 100 mL 2012 rosé in sequence from left to right as pictured.

DISCUSSION

Colour adsorptivity differences between the cellulose depth medium and standard depth medium were obvious, with approximately four times as much colour adsorbed onto the latter using a highly-coloured wine.

The nylon membrane medium likewise adsorbed significantly more colour than PES. In a bottling filtration model, the standard depth/nylon media combination was 60 per cent more colour retentive than the cellulose depth/PES media combination.

While virtually no colour loss was recorded for the PES membrane passes, the nylon membranes showed sequential

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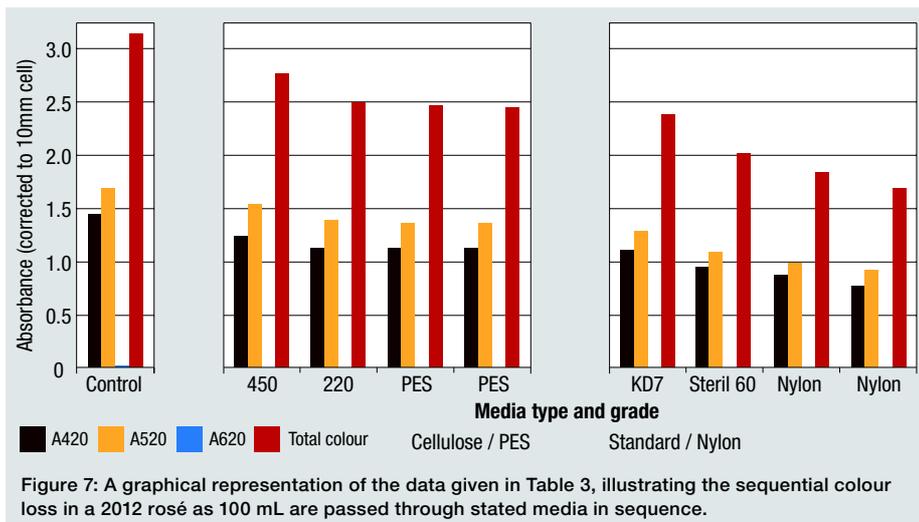


Figure 7: A graphical representation of the data given in Table 3, illustrating the sequential colour loss in a 2012 rosé as 100 mL are passed through stated media in sequence.

colour adsorption with each exposure, which was visually evident (Figure 4).

The fact both 0.45µm nylon discs visually appear the same and exhibit similar quantified colour adsorption indicates pigmented material is actually being adsorbed and retained as opposed to simply being removed from solution due to large particulate size.

The tight standard depth medium also adsorbed a significant amount of pigment from the wine, observable in the bright red colouration of the corresponding second depth disc (Figure 4).

When a lightly-coloured wine (2012 rosé) was passed through

the different media types the colour adsorption was much more evident due to the lower pigmentation in the initial sample. Total colour adsorption by the standard pad material was again approximately twice that of the cellulose medium.

The nylon membrane discs again adsorbed approximately seven times that of the PES discs. Interestingly, colour adsorption by the nylon discs visually approximates that observed for the 2012 Malbec (compare the nylon discs in Figures 4 and 6), indicating nylon membranes are far more damaging to rosé in terms of colour adsorption than PES, since the amount of colour adsorbed on the nylon membranes is similar in both red and rosé wines, irrespective of wine type.

Colloidal additions to wine have the capacity to impact negatively on filtration media (Czekaj, López and Güell, 2000; Vernhet, Cartalade and Moutounet, 2003; Vernhet, Pellerin, Belleville, Planque and Moutounet, 1999), as evidenced by additions of tannin and grape juice concentrate to wines destined for membrane filtration.

Typically colloidal additions do not elevate wine NTU, further emphasising the importance and superior relevance of filterability (FI) measurements as opposed to turbidity (NTU) measurements when additions of this type are to be made.

In SA 2011 was a poor vintage for some reds and these wines

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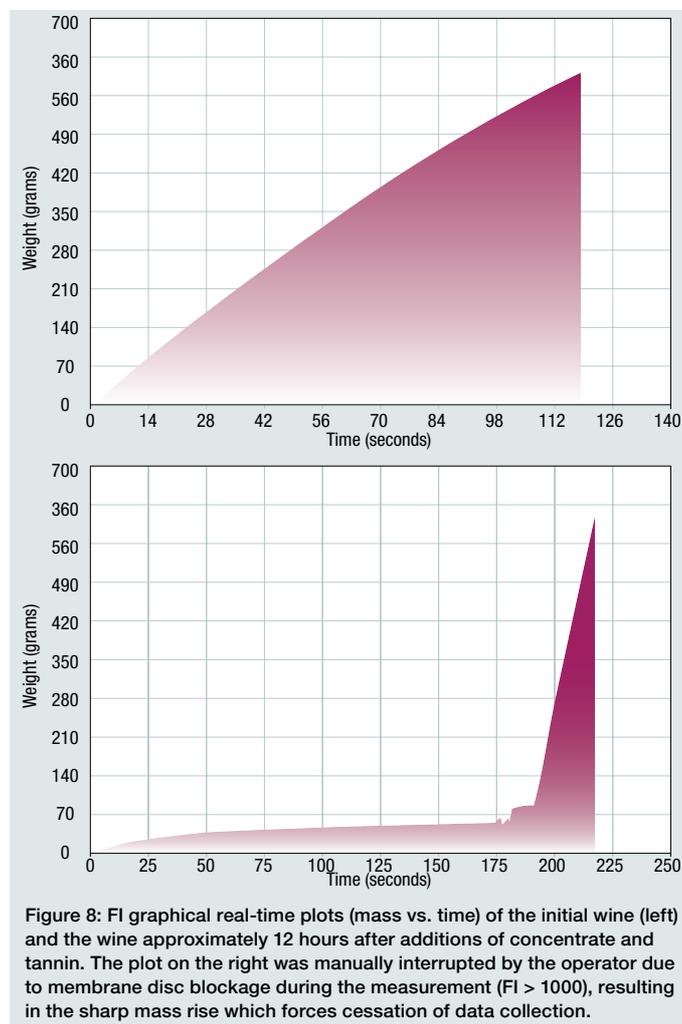


Figure 8: FI graphical real-time plots (mass vs. time) of the initial wine (left) and the wine approximately 12 hours after additions of concentrate and tannin. The plot on the right was manually interrupted by the operator due to membrane disc blockage during the measurement (FI > 1000), resulting in the sharp mass rise which forces cessation of data collection.

can prove problematic during bottling due to the presence of glucans released by *Botrytis* into the fruit.

These polysaccharides are not degraded by pectolytic enzymes and are known to cause membrane fouling, but also have shown themselves capable of fouling depth media as well (Edwards and Eyre, 2013).

CONCLUSION

Clear differences exist in terms of colour adsorption between the different types of filtration media.

Cellulose depth media out-performs standard depth media in terms of colour adsorptivity, and with respect to membranes PES is seen to be vastly superior to nylon in terms of colour adsorption.

FI has proven to provide a vastly superior estimate of the likely impact of a given wine on filtration media than NTU. The reliance on NTU as a means of evaluating wine suitability for membrane filtration is likely to lead to significantly-higher filtration costs for bottlers due to increased media loading.

Wines containing elevated colloidal levels, or where colloidal additions have been made, can lead to media blockage and higher bottling costs.

The move to mainstream use of filterability determinations as an adjunct to turbidity measurement will service both winemakers and bottlers alike due to the greater understanding of wine filterability provided.

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