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WIPES & DISINFECTANTS ARE NOT ALWAYS THE IDEAL MATCH

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Wipe and disinfectant compatibility

Different wipe substrates and disinfectants can interact in ways that can interfere with disinfection efficacy. **Karen Rossington** looks at past studies into incompatibility and what it means in practice

Due to the numerous benefits of presaturated wipes – including ease of use, lowering of VOCs, increased convenience and reduction of hazardous waste – the use of such wipes within the pharmaceutical industry and especially the healthcare industry has proliferated in the past few years. The majority of the original presaturated wipes were alcohol-based and disinfectant presaturated wipes were less widely used. There are now numerous non-sterile disinfectant wipes available, predominantly for infection control use in healthcare environments. There are fewer types of sterile disinfectant wipes available but they are becoming more routinely used in pharmaceutical and biotech industries.

However, do all these wipes perform as well as expected and are the results the same as for the ready-to-use fluids? The addition of a disinfectant to a wipe substrate is not as easy as may first be expected. There are some known problems arising from adding certain disinfectant actives to particular wipe or mop substrates.

Incompatibility between the disinfectant and the substrate: Two disinfectants known to be problematic with wipe and mop materials are chlorine-based disinfectants (such as hypochlorites) and quaternary ammonium compounds. Organic materials consume available chlorine, thereby reducing the disinfectant capacity of chlorine-based disinfectants. This is not a problem when using a fluid straight onto a surface, as providing the surface is cleaned of organic matter prior to disinfection, chlorine-based disinfectants are both fast-acting and effective.

A cost-effective and commonly used presaturated wipe substrate is cellulose or cellulose blends, mainly because cellulose is a relatively cheap material and the wipes provide good absorbency. However, it is a natural organic material and, therefore, theoretically it will use up all the free chlorine if used as the base for a hypochlorite disinfectant wipe.

This was borne out by work carried out in 2007,[1] when cotton wipes and cellulose based wipes were placed in an open bucket system for up to 72 hours (hrs). As bleach can be unstable over time, the testing period was limited to 72 hrs. The study found that after 24 hrs, the amount of chlorine ion released from the cellulose-based wipe was 28% lower than the original bleach solution and the chlorine ion release from the cotton wipes was 11% lower than the original solution.

In comparison, a nonwoven wipe that was tested after 72 hrs had only 3% lower chlorine release, showing that the choice of wipe substrate was key in ensuring how much free chlorine remained and hence the efficacy of the disinfectant solution was not compromised by the wipe substrate. This effect can be even more significant when the wipes are irradiated.

There is a similar issue observed with wipes and mops presaturated with quaternary ammonium compounds (quats) but for a differing reason. R Bloss *et al*[2] conducted a study to look at the absorption of the active ingredients of different surface disinfectants onto different types of fabric.

They compared two different solutions of benzalkonium chloride (quat), gluteraldehyde and propan-1-ol on four different fabrics (polyester/cellulose pulp, viscose rayon, polyester and a mix of viscose, cellulose and polyester). The fabrics were immersed in each solution for up to 24 hrs and then the wipes squeezed in a standardised way to remove the eluate. The eluate was then tested to determine what level of active ingredient was left. Results showed that the quat was strongly absorbed onto both the cellulose-based wipes up to 61% after only 30 mins and the viscose rayon wipes up to 70% after 30 mins. Even the mixed wipes with a smaller amount of cellulose and rayon absorbed 54% after 7 hrs.

Because of its structure the polyester fibre absorbed the smallest amounts of quat: just 17% in 15 mins. It was only with the polyester fibre that the quat solution remained within its working range. The gluteraldehyde and propan-1-ol were not adsorbed by any of the fabrics to any great degree and both solutions remained within their working limits. The paper concluded that an effective surface disinfection regime has to include the selection of an appropriate fabric.

Other research has come to the same conclusion: MacDougall and Morris[3] showed that a nonwoven wipe released an average of 90% of the original concentration of quaternary ammonium solution after 8 hrs but a cellulose-based wipe released only 21% of the original concentration. In a white paper[4], Ecolab surmised this binding of a quaternary ammonium compound to certain fabrics was due to quats being cationic or positively charged surfactants and being attracted to fabric surfaces that are anionic or negatively charged. This results in the binding of a portion of the quat to the fabric and becoming unavailable to disinfect the surface.

The studies went on to discuss various ways in which this problem could be overcome: by careful selection of the substrate; by allowing for the loss and starting with a higher concentration of quat in solution so that the amount released is still above the required kill level; by submersing the wipes for a very short period of time, i.e. dip and wipe method; or by using a very large volume of solution to a small amount of wipe material (not entirely practical).

All of the published work looked at what happened over relatively short time periods for mops and wipes saturated for immediate use. Even over these short time periods a drop in active ingredient was observed that could significantly affect the overall effectiveness of a biodecontamination regime. If there were compatibility issues, these could be severely aggravated by a presaturated wipe, where the fluid is in contact with the wipe for an extended period.

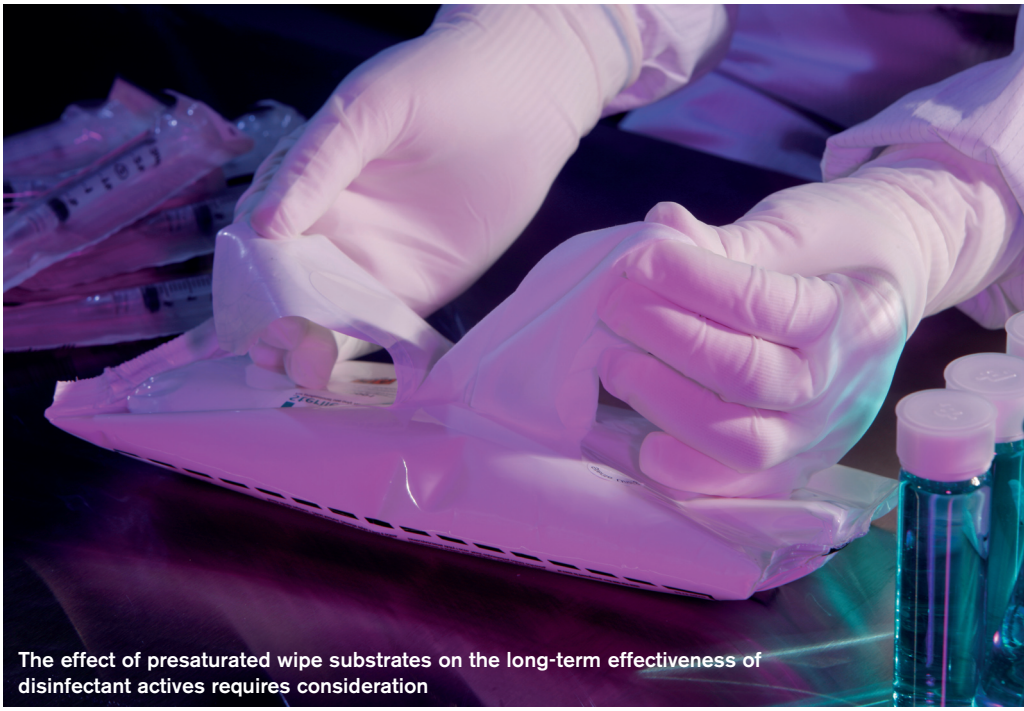
European disinfectant wipe testing: In Europe there is no specific efficacy testing for presaturated wipes. There is a phase 2, step 2 test that incorporates a back and forth wiping procedure across four test areas, simulating in use conditions. However, the test is currently still under development. In the US, both the AOAC and ASTM have standards with published methods for

testing presaturated wipes for microbial activity that are similar in their basic design. However, at the most basic level it would be possible to utilise the existing standard EN suspension and surface tests on eluate extracted from the wipe at the end of shelf life to show that the wipe being in contact with the fluid had not had any adverse effect on the efficacy of the disinfectant.

When evaluating presaturated wipes it is crucial to ensure that efficacy testing has been carried out on fluid extracted from the wipe, otherwise (as the studies have shown) the fabric could have had an unknown detrimental effect on the disinfectant that worked perfectly well as a ready-to-use fluid.

Presaturated disinfectant wipe testing: Work was carried out on a range of sterile and non-sterile presaturated wipes currently on the market to see if there had been any potential negative effect from the wipe on the efficacy of the disinfectant. Wipes at various points within their shelf life were squeezed to a standardised method to remove as much fluid as possible from the wipe and then the eluate was tested against the standard EN disinfectant tests, EN 1276 for bacterial efficacy,[5] EN1650 for fungal efficacy[6] and EN 13704 for sporicidal efficacy.[7] Table 1 shows the results obtained and where the wipe eluate did not reach the required level of efficacy as claimed for the equivalent fluid product.

The contact time to prove sporicidal efficacy against EN 13704 is 60 mins. However, as this does not tend to be practical in use, many companies test at a shorter contact time of between 3 and 15 mins. The test work was carried out at 15 mins, which is a longer contact time than claimed for any of the products tested.



The effect of presaturated wipe substrates on the long-term effectiveness of disinfectant actives requires consideration

As can be seen from these results, many of the wipes tested did not meet the claims made for the equivalent RTU fluid. The tests were performed twice to eliminate any possible error in the testing (all tests did pass validation). In common with the previous studies, alcohol (both IPA and denatured ethanol) worked well in conjunction with a variety of wipe substrates, showing efficacy comparable to claims for the fluid product. The quaternary ammonium-based products showed failures against the fungal test. This would support previous studies that if the fluid used to saturate the wipes has the same active concentration as the RTU fluid, the fact that the quaternary ammonium compound is binding to the wipes could leave insufficient active in the deposited fluid to get the required kill. In all cases there was enough active quat for a bacterial kill but not enough to kill the more resistant fungi.

A similar result was observed for the amphoteric surfactant disinfectants; these are also attracted towards negatively charged fabrics and remain bound to the wipe itself. This can be visibly seen on some of the wipes as the wipe changes colour where the fluid is absorbed. A quick check of pH and colour for the failed products showed that either pH and/or colour had fallen out of the ready-to-use specification.

Hydrogen peroxide is an equilibrium ▶

Table 1: Presaturated disinfectant wipe testing

	Wipe info		Efficacy – wipe extract		
Active ingredient	Wipe substrate	Shelf life at time of testing	EN1276	EN1650	EN13704
Amphoteric surfactant	Polyester / Cellulose	15 months	Fail	Fail	N/A
Amphoterics / Biguanide	Polyester / Cellulose	18 months	Fail	Fail	N/A
Quat / Biguanide	Polyester / Cellulose	8 months	Pass	Fail	N/A
Quat / Biguanide	Polyester / Cellulose	3 months	Pass	Fail	N/A
Quat / Chlorine dioxide	Polyester / Cellulose	10 months	Pass	Pass	Fail 15 min
Hydrogen peroxide	Polyester / Cellulose	8 months	Pass	Fail	Fail
Hydrogen peroxide	Polyester	20 months	Pass	Fail	Fail
Hydrogen peroxide	Rayon blend ?	3 months	Pass	Pass	N/A
Hypochlorite	Polyester	7 months	Pass	Pass	Pass
Hypochlorite	Rayon blend ?	9 months	Pass	Pass	Fail 15 min
IPA	Polyester / Cellulose	14 months	Pass	Pass	N/A
IPA	Polypropylene	4 months	Pass	Pass	N/A
Denatured ethanol	Polyester / Cellulose	11 months	Pass	Pass	N/A
Denatured ethanol	Polypropylene	13 months	Pass	Pass	N/A

Table 2: Summary wiper comparison data

Product	Residue on evaporation/ppm	Product	Residue on evaporation/ppm
Quat / Biguanide wipe	4643	Quat / Biguanide liquid	6106
Quat / Chlorine dioxide wipe	8310	Quat / Chlorine dioxide liquid	20595
Hydrogen peroxide wipe	2269	Hydrogen peroxide liquid	547
Amphoteric surfactant wipe	999	Amphoteric surfactant liquid	62213
Quat / Biguanide wipe	4841	Quat / Biguanide liquid	5256
Amphoterics / Biguanide wipe	538	Amphoterics / Biguanide liquid	5948
IPA wipe	197	IPA liquid	1
Denatured ethanol wipe	94	Denatured ethanol liquid	25
IPA wipe	50	IPA liquid	0
Denatured ethanol wipe	53	Denatured ethanol liquid	2
IPA wipe	296	IPA liquid	6

◀ product where contact with certain materials is likely to start the decomposition process, known as "gassing off". Hydrogen peroxide breaks down to water and oxygen, and this decomposition process can leave a wipe with little to no activity and a pouch overfilled with air (oxygen) as shown in Figure 1. This could be the cause of the lack of activity observed for the hydrogen peroxide wipes.

A quick check of the percentage of hydrogen peroxide in the products that had failed showed that the level of hydrogen peroxide had dropped out of specification, down as low as 4.42% instead of a specification of 5.5%–6.5%. Interestingly, for hypochlorite-based products, where a significant interaction is well known, one of the wipes behaved well because the substrate chosen was polyester so there was no organic material to cause an adverse effect on the efficacy, and the other failed against spores.

Previous studies used HPLC and gas chromatography to assess whether there was a lower percentage of active ingredient in the eluate removed from the wipe. A more basic assessment was carried out in this instance, merely comparing the residue on evaporation (EP method) for the original fluid with the fluid removed from the wipes. With the exception of the alcohols and the hydrogen peroxide, the active ingredients in the disinfectants will leave a residue on the surface. What these results show (Table 2) is that in all cases the residue on evaporation for the fluid from the wipe was significantly lower than the residue on evaporation from the ready-to-use fluid – showing that a significant portion of the active material had been retained on the wipe.

Effect on the wipe substrate itself: While the wipe can have an effect on the fluid, the fluid can also have an effect on the wipe. Some of the more aggressive surface disinfectants have the ability to break down the wipe substrate, allowing it to generate more fibres and particles. Careful choice of substrate can significantly reduce or eliminate this problem. To see if the wipes that had poor efficacy results had been broken down, a test was carried out using a biaxial shaker to remove particles from the wipes and then the fluid was analysed using a liquid particle counter. The particles were extracted from the wipe in accordance with the procedures in IEST-RP-CC004.3[8] using a Gilson Sieve Shaker. The number of particles in the fluid were then analysed using a Hiac/Royco 3000A/8000A liquid syringe sampler.

In one particular case there was visible degradation of the wipe: the number of particles in the extract fluid were so great that they were visible in the fluid itself, showing that there had been a significant breakdown of the wipe material. The cloudiness that can be seen in Figure 2 is caused by particles suspended in the fluid. The beaker on the left contains liquid extracted from one of the sporicidal wipes on a polyester/cellulose substrate; the beaker on the right contains alcohol solution as a comparison.

Results from the particle counter showed that polyester/cellulose wipes presaturated with a range of disinfectants released more particles than when the wipes were dry, and some fluids affected the wipe material more than others. Polypropylene wipes that were presaturated with alcohol did not release significantly more particles than the dry equivalent wipe.[9]

In conclusion, as can be seen from the results of this and previous studies, careful consideration should be given by manufacturers to the effect of presaturated wipe substrates on the long-term effectiveness of the active ingredients. Simple testing of the fluid extracted from the wipe at the end of shelf life would show whether any decomposition or binding of the active was occurring. Efficacy testing carried out on the extract fluid at end of shelf life would confirm that there has been no detrimental effect on the efficacy of the disinfectant over time. Presaturated wipes have significant benefits over sprays and dry wipes for the application of disinfectants but a customer must be sure that one and one does equal two when a disinfectant is added to a wipe or mop. CT

Figure 1

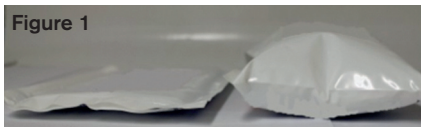
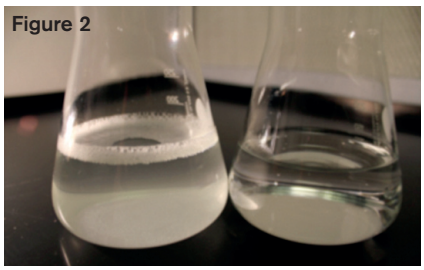


Figure 2



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