Comparison: Mixed Oxidant Solution and UV

Both mixed oxidant solution (MOS) and ultraviolet (UV) disinfection can be used for water treatment, or the two processes can be used in conjunction. Chemical disinfectants like MOS destroy or damage microbial cell structure through a process known as “cell lyses”. In contrast, UV lamps operating largely at the 253.7nm wavelength “inactivate” microorganisms by overwhelming the repair enzymes in their DNA, thereby inhibiting microbial replication. The advantages unique to MOS are biofilm removal and enhanced chlorine residual maintenance (note that UV will not leave a chlorine residual). MOS also improves taste and odor and reduces Total Trihalomethane (TTHM) formation in contrast to the conventional chlorine alternatives (gas & bleach). The two principal benefits of using UV disinfection in potable water supplies are inactivation of *Cryptosporidium* at relatively low doses and even further reduced formation of TTHMs over MOS.

MOS provides a more comprehensive disinfection solution in a single-step process than UV. Disinfection efficacy of UV is affected by turbidity (particles) and by fluctuating water transmittance (UV-absorbing compounds) in the water stream. In many cases, the user may be able to achieve his/her goals with the use of MOS alone.

If UV is chosen for primary disinfection of potable water for either *Cryptosporidium parvum* oocyst control or reduction of TTHMs, it must be used in conjunction with a secondary disinfection agent to provide the necessary chlorine residual in the distribution system. MOS disinfection is an ideal choice as this secondary step because it provides both enhanced chlorine residuals and control of biofilm in the distribution system, without introducing a hazardous material into the treatment process.

	MOS	UV
Residual / Dose	• Durable chlorine residual lasts much further and longer in the distribution system than traditional chlorine solutions • A chlorine residual is added without the need for a secondary disinfection technology • Oxidant demand in contrast to chlorine is decreased -- i.e., a lower chlorine dose (typically 33% less) will maintain the same, or higher chlorine residual in the distribution system due to MOS’s effect of mitigating biofilm growth	• Leaves no measurable residual disinfectant for protection against recontamination or biofilm growth in the distribution system • Must operate excess equipment to ensure appropriate UV dose is delivered, under all water quality conditions, since system is designed on a “once-through” basis to ensure that photoreactivation of DNA (light repair) does not occur

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	MOS	UV
Disinfection Effectiveness	• Very effective against a wide range of viruses and bacteria • Also effective against "hard-to-kill" protozoan cysts, including *Giardia* and *Cryptosporidium*, but use of chlorine Concentration x time (Ct) tables is currently required with MOS • In actual practice, disinfection efficacy is 2-10 times higher than chlorine at the same dose • Lower dosage required than with chlorine for same or higher residual	• Very effective against *Giardia* cysts and *Cryptosporidium parvum* oocysts at low UV doses (~4 mW-s/cm^2) • Ineffective against Adenovirus and others at normal doses • Disinfection is adversely affected by water quality parameters such as: low UV transmittance, high alkalinity, colloidal materials, UV absorbing compounds (NOM), turbidity and suspended solids • Certain microorganisms are capable of repairing the damage caused by UV and reverting back to a viable state • Carbonate in raw water and biofilms (dead) can be deposited on UV quartz tube surfaces, reducing UV output and impacting operational integrity • TOC in the form of humic and fulvic acids absorb UV, reducing UV disinfection effectiveness • Clumping of microbes and color in the water can affect efficacy • Non-uniform flow conditions in reactors can create dead zones w/ inadequate hydraulic mixing, leading to poor disinfection
Regulatory	• Is an EPA-compliant technology • Inactivation credits granted on the basis of chlorine content • All equipment is NSF-61 approved • Leaves a chlorine residual to comply with federal and state regulations	• Is an EPA-compliant technology • Regulatory agencies have not determined inactivation credits for certain microbial contaminants – new ones are constantly being assessed due to the relative "newness" of UV-pathogen interaction pathways • Use in drinking water must be followed with a chlorine technology for residual maintenance
Biofilm & Algae Removal	• Removes existing biofilm from storage tanks and distribution system and prevents biofilm regrowth • Counteracts taste and odor effects of algae blooms • Removes a cause of DBP formation in distribution system • Improves residual maintenance • Can be used to control biofilm accumulation on MF/UF/NF membranes and newer membrane processes (i.e., submerged membrane bioreactors), leading to extended filter run times and higher operating fluxes	• No effect on biofilm in distribution system although will kill biofilm in direct contact with UV light • Ineffective against algae and biofilm in cisterns and clarifiers unless UV is in direct contact with all surfaces, which is not done, for practical purposes

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Microflocculation	• Can cause microflocculation effect thereby decreasing alum dosing by up to 40% while simultaneously decreasing final turbidity • Can reduce sludge handling requirements • Improves filter runs • Use in pretreatment typically decreases organic precursors, reducing final DBP levels by up to 50%	• Considered sometimes as a primary disinfection option for raw water supplies for surface water treatment facilities
Taste & Odor	• Reduces complaints due to taste and odor • Effective against taste problems caused by algae blooms • Rapidly oxidizes sulfides • Minimizes formation of odorous di- and tri-chloramines • When using MOX, chlorine taste usually not evident even at chlorine residuals > 3 ppm	• Does not leave a chlorine taste or odor; however, UV in combination with a strong oxidizing agent (i.e., MOS or hydrogen peroxide) will reduce taste/odor problems associated with algae blooms, MIB and/or geosmin • No known direct oxidation of hydrogen sulfide
Oxidation of Other Compounds	• Will rapidly oxidize iron and manganese, allowing removal by coagulation • Achieves breakpoint oxidation at lower chlorine-to-ammonia ratios than liquid bleach • Rapidly oxidizes sulfides	• Not known to oxidize iron, manganese, or hydrogen sulfide • Advanced oxidation processes may be used to dissociate ammonia in the water supply
Easy to Maintain	• Fully automated unit requires minimal training or attention –maintenance time reported by customers is 2 hours weekly • Excellent customer service record recognized in the industry • Cell replaced every few years – takes only 10 – 20 minutes • Oxidant used as produced so there is no deterioration in oxidant strength/concentration under normal operating conditions	• Frequent cleaning and regular component replacement is required • Aging of the lamps (average life of low pressure lamps is 8,760 hours, 1-year) or fouling of the lamp surface due to carbonate scaling and biofouling can reduce UV output dramatically, so lamps must be continually cleaned and maintained
	• No mixing or diluting of disinfection solution is required • No ionic membranes, or complex cleaning processes are required • No safety equipment is necessary • HAZMAT training not required	• Requires addition of a secondary disinfection agent since a chlorine residual is required for drinking water applications • Chlorine is often used in plant for filter cleaning and filamentous bacteria (nocardia) control • UV lamp On/Off cycles should not exceed four times per day, or filaments in the lamp can have a drastically reduced life • Minor current fluctuations even for a fraction of a cycle can extinguish UV lamps, particularly medium pressure lamps, which require up to five (5) full minutes of operation to achieve specified UV output – most UV lamps require a 3-5 minute cool down/restart sequence upon power loss

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Economical	• Lifecycle costs are comparable to chlorine gas and typically less than ozone or chlorine dioxide • Reduced oxidant demand (in contrast to chlorine) typically means operating costs will be 30% less than estimated • Positive effect on other plant processes can save significant dollars in O&M operations • No liability costs or expenses for safety training or equipment	• Small to mid-size plants (1-20 MGD) typically use low pressure (LP) or low pressure high-output (LPHO) lamps, whereas larger sites (>20 MGD) typically use a medium pressure (MP) lamp. MP systems require fewer lamps to disinfect greater flows of water at the same dose; however, they also require substantially higher power input and maintenance • UV systems are in general more expensive, both in capital cost and operating expenses
DBP Formation	• MOS reduces TTHM and HAA5 production by 30% to 50% in contrast to chlorine alternatives • Does not form chlorite or bromate	• Not known to form any DBPs
Safety	• Neither uses nor produces hazardous chemicals – only salt, water, and power required for oxidant production • Eliminates storage and handling of chlorine gas or bulk sodium hypochlorite • No Risk Management Plan (RMP) is required and other safety requirements associated with chlorine gas and bulk bleach are not applicable.	• Eliminates regulations associated with storage of chlorine, unless chlorine is used as a secondary disinfectant for residual maintenance, plant process cleaning and/or bacteria control • Exposure to UV light is dangerous, safety equipment for skin/eyes is required