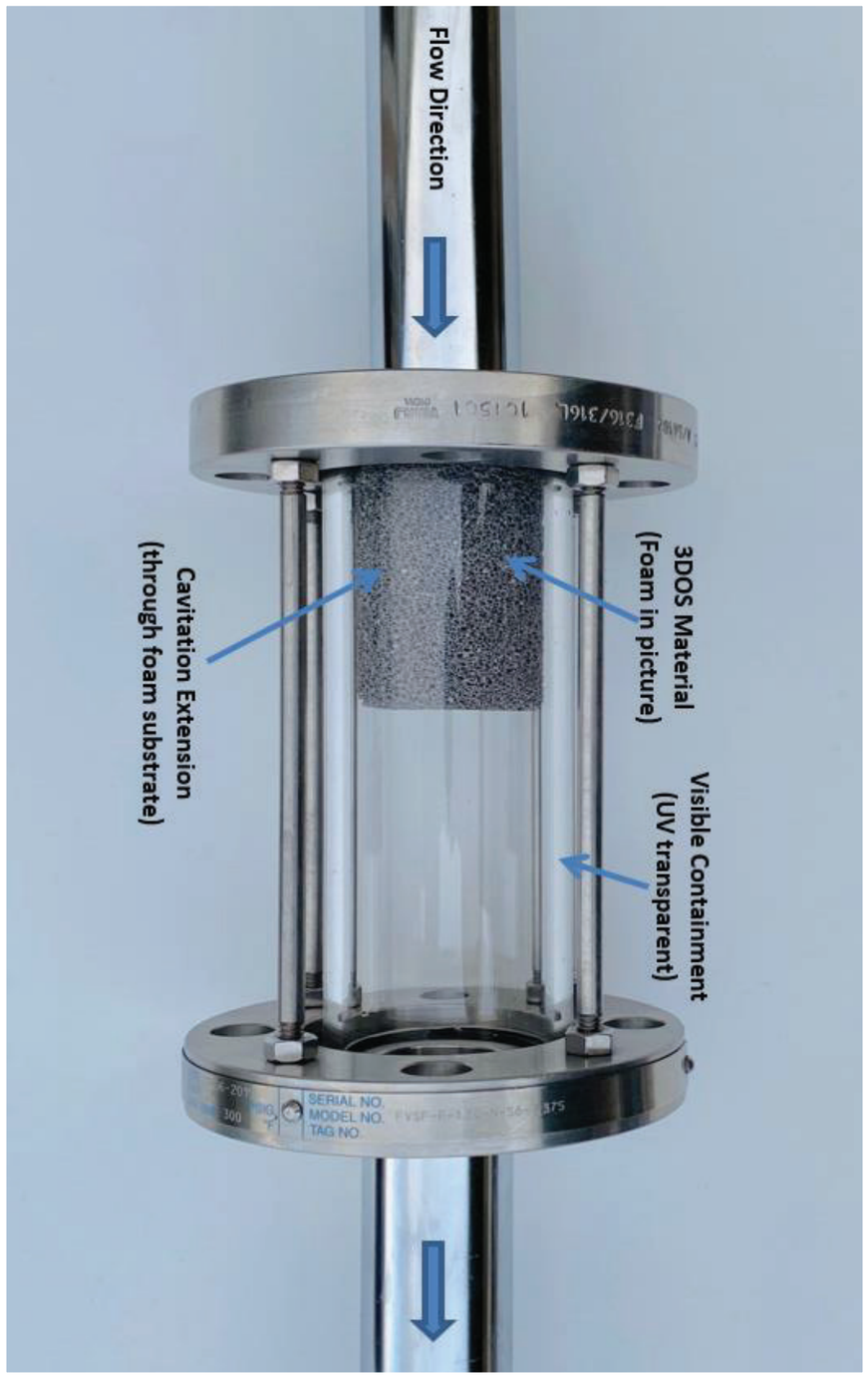

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Clean Water and Fluids from any Source

OPERATIONAL PRINCIPLE OF THE 3 DIMENSIONAL OPEN STRUCTURE (3DOS) SUBSTRATES CONCEPT WITH RESPECT TO THE DESTRUCTION OF TRACE CONTAMINANTS IN WATER

BACKGROUND

Many types of technology have been developed to deal with the issue of chemical contaminants in water. This is due in part to the wide range of these contaminants that result from the many uses of water. Contaminated water from agricultural use, municipal systems, industrial operations, and transportation all contribute to the problem, but result in different contaminants. This makes the problem of water cleanup for reuse difficult because certain concepts and mechanisms are required to deal with the uniqueness of each type of contaminant species. Inorganic salts, such as arsenics, nitrates and sulfates, are different than organic materials, such as halogenated hydrocarbons, which are different than biological species with respect to the method of treatment required to meet the environmental standards. However, in every instance, trace quantities of these contaminants which are either too difficult to destroy or have a high level of toxicity, become the critical determinant in the processing treatment in order to reach water cleanliness suitable for human consumption. Costs associated with the incorporation of multistep processes, or addition of reactants, or expensive equipment results in expensive operations. A novel approach to reduce the complexity and increase the effectiveness in treating difficult contaminant, with the potential for low cost, is currently under development and explained here.

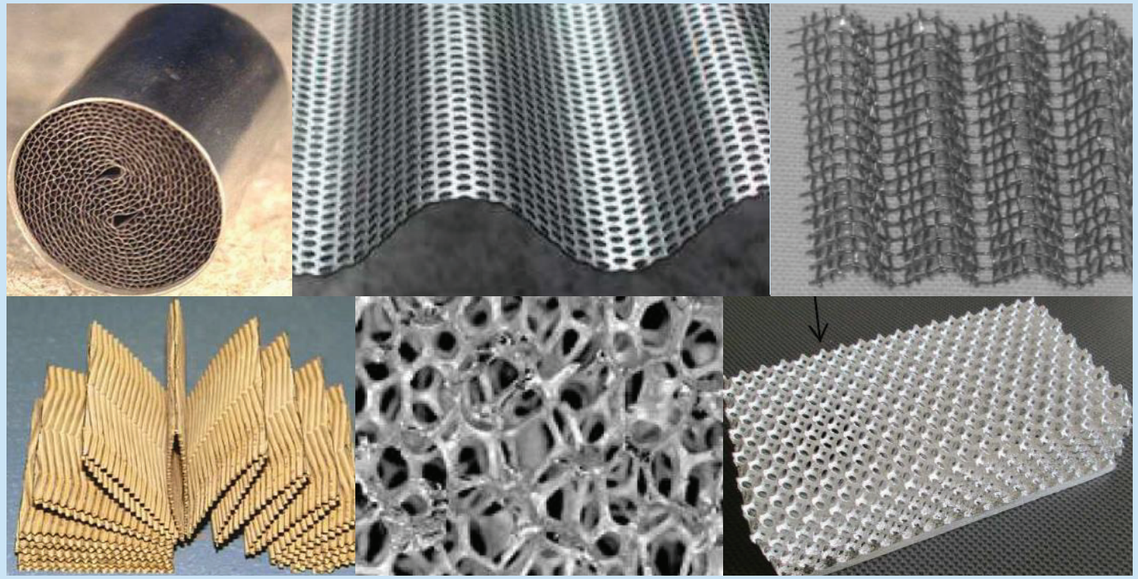
DESCRIPTION OF TECHNOLOGY

One of the least invasive approaches to destroying organic molecules in water is use of cavitation. Cavitation is a condition that is produced by the creation of areas of extremely rapid change in pressure in a liquid medium. Cavitation can be produced via hydrodynamic or ultrasonic conditions. The result of cavitation in water is the production of localized areas of water vapor, hydroxyl radicals and very high temperatures, all of which creates a very chemically reactive condition. In normal operations, the results can be the destruction of organic molecules, due to the chemically reactive species generated at the cavitation source. However, the area of cavitation is normally very limited and therefore its applicability to destroy organic contaminants, in the process of water cleanup operations, requires the implementation of recycle. In order to expand the area of cavitation, i.e., chemically active area, the inclusion of 3-dimensionally open structure (3DOS) support immediately downstream of the initiation of cavitation will maintain the cavitation/active area over an extended distance and enhance the extent of destruction of unwanted organic contaminants. The result would improve the effectiveness of organic species destruction in a one-step, single pass through the reactive area.

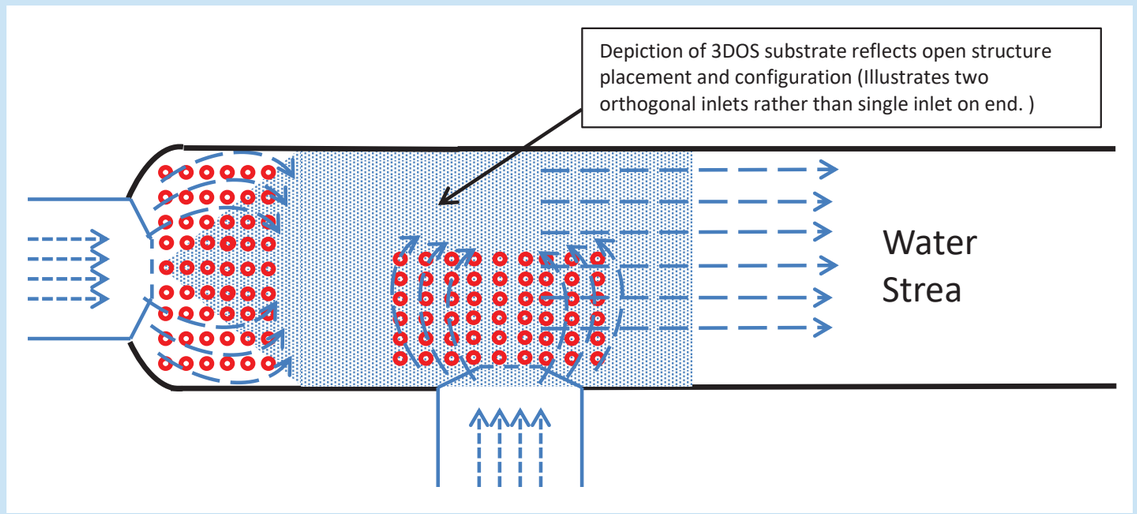
However, there are several additional advantages to the inclusion of 3DOS in an area of cavitation initiation, particularly when hydrodynamic cavitation is employed, e.g., water flow through an orifice. First, the design of the 3DOS structural support can provide the areas of cavitation in much the same fashion as the source. Second, the porosity of the 3DOS can be varied to change the degree of cavitation by incorporating the advantage of tortuous flow patterns. This can be achieved by various designs and materials, and will result in an expansion of reaction zones within the porous structure. Third, the surface of the 3DOS material chosen can be catalyzed to enhance specific chemical reactions taking place as the water flows through the structure. Fourth, when installing the 3DOS within a quartz tube, UV light can be directed onto the flowing reaction area and provide the additional reactive condition of photochemical activation. All of these features can be incorporated into a flow tube, thereby providing a unique combination of methods by which the organic contaminants can be destroyed during a single pass, thereby reducing recycle necessity.

ILLUSTRATIONS

The choice of 3DOS to be employed in the water decontamination process is broad and can be tailored to the particular operation that is employed. The figure below illustrates many of the options that are available.



There are several ways that 3DOS can be employed in water cleanup operations. In the figure below, some options are illustrated for multiple flow patterns that can be implemented to achieve the desired reactive conditions necessary for destruction of the undesired species.



Preliminary tests were conducted that utilized a nozzle as the cavitation initiator and a metal foam 3DOS substrate to determine the potential for destroying halogenated hydrocarbons. The results, shown below, illustrate the potential for a combined hydrodynamic cavitation source and 3DOS for waste water cleanup. The information on the left-hand column shows the operational effect of 3DOS on the destruction of each of the four compounds listed. The information on the right-hand column shows the effect of the combined cavitation and 3DOS, ie., a 96-98% overall destruction with the inclusion of 3DOS, compared to only 29-38% without 3DOS inclusion.

NOZZLE ONLY (WITHOUT 3DOS)

Bromodichloromethane

Lower Concentration		Higher Concentration	
Before	After	Before	After
150	ND	630	10

Bromoform

Lower Concentration		Higher Concentration	
Before	After	Before	After
170	20	680	77

Chloroform

Lower Concentration		Higher Concentration	
Before	After	Before	After
130	81	550	390

Dibromochloromethane

Lower Concentration		Higher Concentration	
Before	After	Before	After
170	3	700	14

29 - 38% reduction in halogenated species (ppm)

NOZZLE WITH 3DOS

Bromodichloromethane

Lower Concentration		Higher Concentration	
Before	After	Before	After
130	ND	510	ND (<8)

Bromoform

Lower Concentration		Higher Concentration	
Before	After	Before	After
130	ND(<15)	520	ND (<59)

Chloroform

Lower Concentration		Higher Concentration	
Before	After	Before	After
110	1.9	430	17

Dibromochloromethane

Lower Concentration		Higher Concentration	
Before	After	Before	After
140	ND(<2.5)	590	ND (<12)

96 - 98% reduction in halogenated species (ppm)

ANTICIPATED APPLICATIONS

As discussed, the effect of cavitation on organic compounds destruction in water is via oxidation to produce oxides, i.e., carbon dioxide and water, from hydrocarbon species. The advantage is that with no addition of additional chemicals, pharmeceuticals (e.g., prescription drugs in residential/commercial water, trace contaminants in industrial operations), pesticides, halogenated hydrocarbons, solvents and other toxic contaminants can be destroyed. The advantages of applying 3DOS are (1) multiple passes are reduced due to the extension of the cavitation effects, (2) catalyst incorporation enhances the rates of reaction, and (3) incorporation of UV will enhance the rates of reaction and simultaneously destroy biological species present in the stream. All of these effects, or individual operation, can be implemented, dependent on the configuration of the simple, single-pass, arrangement. Below is a depiction of the inclusion of a metal foam segment in a configuration that could implement the UV application.