

## DEXSORB+

### A High Affinity Adsorbent for the Removal of PFAS from Water

#### Features and Benefits

DEXSORB+ reduces PFAS (poly- and perfluoroalkyl substances) to non-detect levels (1–5 ppt) in water samples impacted with environmentally relevant concentrations. Its advantages offer very high operating capacity, excellent kinetics, and ambient-conditions regeneration. It works efficiently against both short and long chain PFAS (Figure 1) and its performance is not affected by natural organic matter or other water constituents. Isolated in a powder form, DEXSORB+ has been adapted to multiple formats (e.g., granules and extruded blocks) for use in water applications for Analytical Testing, Household Filtration, and Municipal Water Treatment. DEXSORB+ has been applied in diverse water matrices, including drinking water, groundwater, surface water, wastewater, and leachate systems.

#### Chemical and Physical Characteristics

Polymer Structure	crosslinked cyclodextrin
Appearance	yellow powder & granules
Adsorption Mechanism	hydrophobic & electrostatic
Surface Area	up to 450 m <sup>2</sup> /g
Avg. Apparent Density	0.56 g/cc
Effective Size (powder)	avg. 78 μm
Effective Size (granules)	212 – 500 μm; 500 – 1500 μm
Temperature Limit	300 °C (572 °F)

#### Strong Affinity for PFAS

DEXSORB+ has demonstrated high adsorption and capacity for PFAS. Isotherm data for PFAS on DEXSORB+ (Figure 2) shows q<sub>max</sub> for PFOA and PFOS above 180 mg/g and 90 mg/g for GenX (Figure 2), showing its ability for removal of short and long chain PFAS and PFAS alternatives of rising concern. Values also correspond to removal data showing high affinity of DEXSORB+ for PFAS at low concentrations, making it suitable for concentrations levels found in actual drinking water and wastewater environments. Based on these outcomes, NIEHS awarded the Company a \$1 million Phase II SBIR grant to continue the development of its DEXSORB+ adsorbent for removal of PFAS from drinking water.

#### Excellent Kinetics & High Operating Capacity

Kinetic studies show that removal performance for most PFAS reaches equilibrium within five minutes. Furthermore, the efficiency and kinetics of PFAS removal are not affected when DEXSORB+ powder is incorporated in other form factors, which the company has developed for direct incorporation in columns for in flow water filtration systems.

#### Large Scale Manufacturing

Through a collaboration with Argonne National Laboratories (ANL), DEXSORB+ has been optimized for large scale synthesis, permitting pilot scale production up to 10 kg quantities. Cyclopure has installed pilot capabilities to begin producing 5 kg/week beginning in March 2020. With the easy transition to large scale established by ANL, we are making preparations for production of DEXSORB+ to support volume requirements for municipal water treatment applications.

#### Form Factor Versatility

DEXSORB+ is made in powder form and can be applied in multiple forms, such as granular, filter paper, and extruded block. All of these form factors are suitable for environmental testing and monitoring applications, as well as drop-in solutions for household filtration products, which require rapid removal and short contact times – advantages available with DEXSORB+. Granules can be prepared in various particle size ranges, including standard 12x40 mesh implementation, creating solution opportunities for municipal drinking water and wastewater treatment systems.

#### Highly Effective Across Multiple Water Matrices

Matrix effects of ground water, surface water, and wastewater effluents on DEXSORB were evaluated in head-to-head comparison against Granular Activated Carbon (GAC). In real water samples, Cyclopure's polymers outperformed GAC over all performance metrics, exhibiting greater capacity and lower susceptibility to fouling, parameters that are critical measures for an efficient large scale treatment.

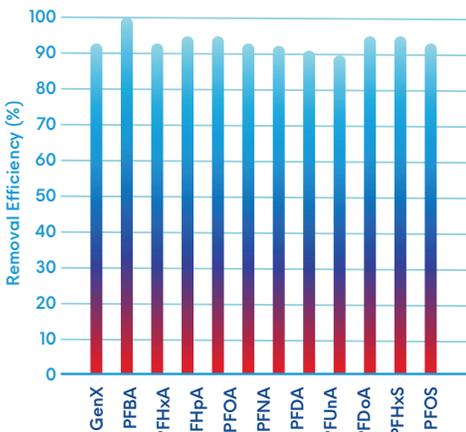
## Rapid-Scale Small Column Tests (RSSCTs)

Packed bed filtration (PBF) is a major adsorption process used in municipal drinking water and wastewater treatment. It provides full access to the advanced features of DEXSORB+ by converting the rapid kinetics and fouling resistance to high bed volumes and in-situ regeneration. The rapid small scale column tests (RSSCT) are specifically designed to simulate a pilot scale PBF with a fast empty bed contact time (EBCT) of 5 minutes. A real groundwater sample containing a total of 125.1 ppt PFAS (PFOA: 18.1 ppt; PFOS: 21.8 ppt) was treated for >90,000 bed volumes (Figure 3). DEXSORB+ showed a capacity of >55,000 bed volumes for the combined treatment of PFOA and PFOS, exhibiting a use rate of 6 mg/L. These results show the superior capacity of DEXSORB+ and how it is a highly effective adsorption material for the removal of background PFAS in real groundwater samples. Additionally, the facile in-situ regeneration of DEXSORB+ in PBF can increase its treatment capacity further by ~5 times, minimizing CO2 footprint and total life cycle cost.

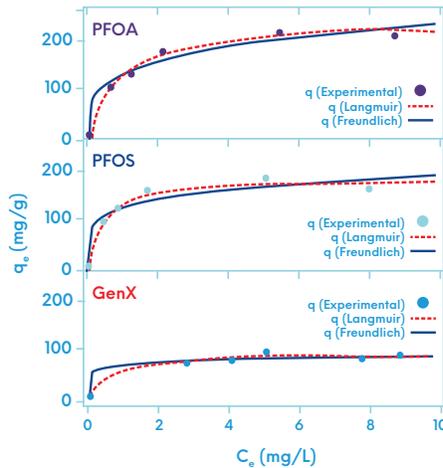


## PFAS Water Test Kit and Other Analytical Uses

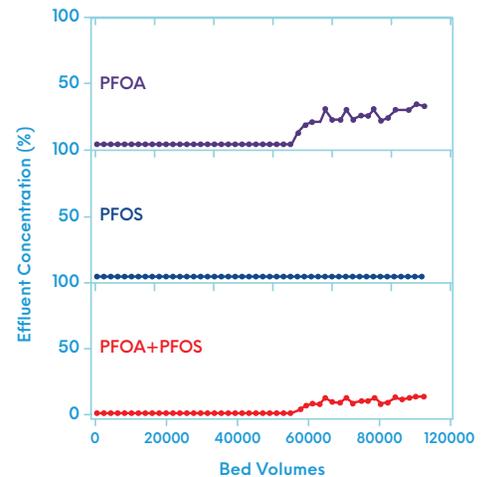
The successful application of DEXSORB+ to filter paper formats has enabled the company to include its adsorbent in home water test kits and consumer filter cartridges. Cyclopure's first product to market is a PFAS Water Test Kit, which uses DEXSORB+ in an extraction disc that allows for the processing of a 250 mL water sample in rapid time. The test is designed based on passive sampling methods and is a first ever home kit that does not require the collection and shipment of water samples to a third party lab for analysis. DEXSORB+ is now also used in granular form in a water flux cartridge offered by iFlux of Belgium in a passive sampling system for PFAS monitoring and measurement in groundwater.



**Figure 1. Effective removal of all PFAS**  
 PFAS Concentrations: 1 ppb per contaminant  
 Dosing: 10 mg/L DEXSORB+  
 Contact Time: 30 min



**Figure 2. Adsorption Isotherm**  
 $q_{max}$  = maximum uptake  
 PFOA  $q_{max}$  = 241 mg/g; PFOS  $q_{max}$  = 188 mg/g;  
 GenX  $q_{max}$  = 93.9 mg/g



**Figure 3. RSSCT (groundwater sample)**  
 PFAS Conc.: tot. 125.1 ppt (40 ppt PFOA + PFOS)  
 Particle Size: 175 – 250  $\mu$ m  
 EBCT (empty bed contact time): 5 min



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