



REGENESIS

Advanced Technologies for Groundwater Resources

March 2007

Dear Environmental Professional:

I am writing this letter to clarify claims being made in advertisements that you may have seen on a product named EHC-O™ marketed by a company called Adventus. Claims made by this company attempt to compare this product to the RegenesiS products Oxygen Release Compound (ORC®) and ORC Advanced®.

Over the past decade similar situations have occurred- where a vendor mixes simple, low priced commodity chemicals and “pushes” them in the marketplace with exaggerated claims in hopes of skimming off a sale to unassuming engineering firms. In the past each of these attempts eventually ended in the engineering firms becoming wise to the exaggerations. I am certain that this case will be no different.

I have attached a summary description of ORC and ORC Advanced as well as a description of EHC-O. I have also addressed the specific claims made by Adventus in the following document.

If you have any questions regarding any of the statements made in this attachment or any comments on the matter please feel free to contact me.

Sincerely,

Scott B. Wilson
President & CEO

Executive Summary

ORC and ORC Advanced are products designed specifically to release oxygen, in a controlled fashion, into groundwater to stimulate cost effective *in situ* bioremediation of hydrocarbon contaminants. Both products employ Regenesis' patented controlled release technology (CRT™)¹. Without CRT, solid peroxygen compounds, such as magnesium peroxide and calcium peroxide liberate their oxygen rapidly. This results in significant oxygen loss or waste with the oxygen simply bubbling out of the groundwater with little lateral movement.

The EHC-O product is a blend of commodity calcium peroxide and a mineral filler material (20% to 30%). It has a rate of oxygen release consistent with simple calcium peroxide. It will release 50% of its available oxygen within the first 21 days, and 80% of its oxygen in the first 70 days. This mass of oxygen will, in most cases, exceed the solubility of the groundwater and rapidly bubble off to the atmosphere. The marketers of EHC-O acknowledge this by recommending that the material be reapplied every 90 days.

When comparing the project costs of employing EHC-O to that of ORC Advanced it becomes clear that costs associated with EHC-O are significantly higher. This is due primarily to the inefficiency of oxygen delivery and to the costs associated with multiple re-application.

Other claims made by Adventus regarding superior pH buffering and nutrient content of EHC-O compared to Regenesis products are simply false.

ORC and ORC Advanced

Regenesis' products are made from primary raw materials in solution and spray dried in a unique patented manner to encapsulate the phosphate that controls the oxygen release¹. In the case of ORC, the product is a form of magnesium peroxide (CAS # 14452-57-4) with the CRT. In the case of ORC Advanced the product is a form of calcium oxyhydroxide (CAS #682334-66-3) with the CRT. Our products are manufactured on three continents and have been successfully employed to restore hydrocarbon contaminated groundwater on over 14,000 project sites around the world over the past decade.

The oxygen release profile of ORC and ORC Advanced shows a very controlled, rather constant rate of oxygen released from the time of injection to about 9 months to 12 months time depending on site conditions. This release profile has been documented on hundreds of project sites where engineering firms have accumulated data. Table 1 presents actual field data collected by a third-party engineering firm documenting the

¹ US Patent #5,264,018

longevity of the oxygen release profile for ORC Advanced applied on a hydrocarbon contaminated site (reference available upon request).

Table 1. Example of ORC Advanced® In-Field Dissolved Oxygen (DO) Levels

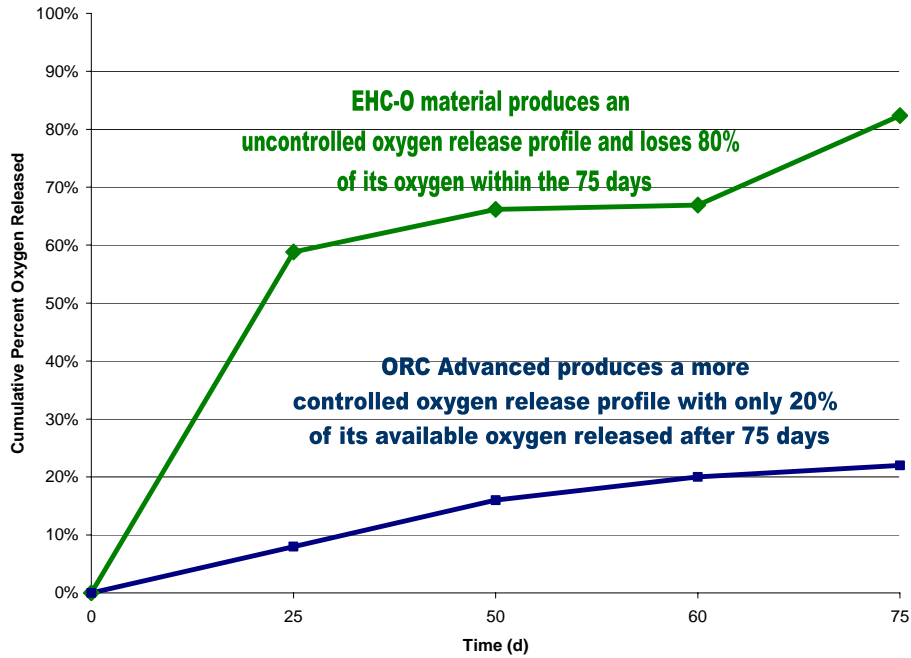
MW065		
Date	Water Level	DO
	(ft above MSL)	(mg/l)
Aug-04	222.26	0.28
Oct-04	225.73	1.21
Dec-04	223.86	12.76
Mar-05	223.04	19.51
Jun-05	226.03	14.79
Oct-05	219.20	1.83

← **ORC Advanced
Single Application Event**

Data from third party engineering firm on actual
in situ remediation program employing ORC Advanced

It is important to realize that EHC-O is simply a blend of commodity calcium peroxide with 20% to 30% of a mineral filler added (presumably a low cost zeolite). The marketers of EHC-O indicate in their literature that 50% of the oxygen liberated from the material does so in the first 21 days after application. A full 80% of the oxygen is liberated from EHC-O in the first 70 days. This is fairly consistent with oxygen release profiles of calcium peroxide. However, this amount of oxygen released in most aquifer settings will not distribute, but rather simply bubble out of solution after exceeding the aqueous solubility of oxygen. It is for this reason that the marketers of EHC-O recommend re-application of the material every 90 days. Figure 1 shows the comparative oxygen release profile for EHC-O (generated from data provided by Adventus) and ORC-Advanced for the first 75 days of release. Note that after 75 days 80%-90% of the oxygen is released from EHC-O. ORC Advanced, on the other hand has released only 21% of its oxygen in the same time frame.

Figure 1. Comparative Oxygen Release Profiles



By applying a single application of ORC or ORC Advanced, engineering firms throughout the world have come to realize cost savings for their clients when compared to attempting to stimulate *in situ* bioremediation with multiple applications of fast releasing chemicals.

Discussion of EHC-O

Composition of EHC-O: *Simple calcium peroxide and 20%-30% inert filler material.* You will find below (Figure 2) an excerpt from the first page of the Material Safety Data Sheet (MSDS) for the EHC-O material (referenced from the Adventus website 3/09/07). Please note that the active ingredient in EHC-O is, in fact, CaO_2 (calcium peroxide). Whenever calcium peroxide is manufactured, calcium hydroxide is present so that's why you also have the $\text{Ca}(\text{OH})_2$ listed on the MSDS. However, the third item listed as 20% to 30% of the material composition has nothing to do with oxygen release and is, in fact, a mineral product that has little benefit beyond a filler material. This is most likely a very inactive and very low cost zeolite material.

Figure 2. EHC-O™ MSDS Reference – 20-30% Filler Material

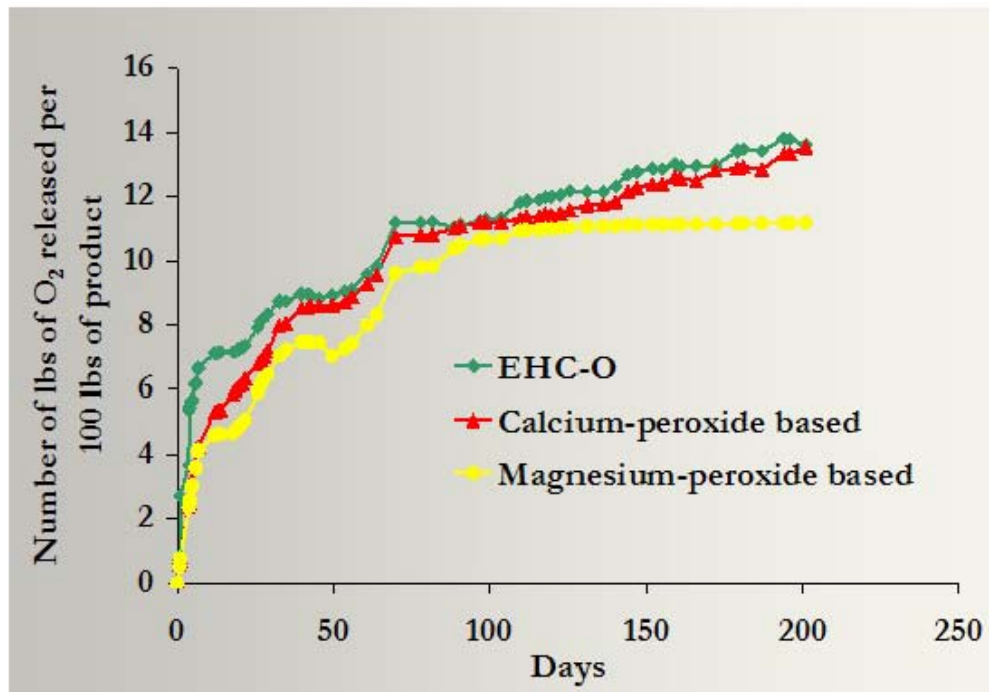


MATERIAL SAFETY DATA SHEET: EHC-O™ Page: 1 of 5

1. **PRODUCT IDENTIFICATION:** EHC-O™
PRODUCT USE: Soil and water treatment.
- MANUFACTURER:** **EMERGENCY PHONE:**
- Adventus Americas Inc. USA: 1-800-424-9300 (CHEMTREC®)
2871 W. Forest Rd., Suite 2 Canada: 1-613-996-6666 (CANUTEC)
Freeport, IL
61032
- TRANSPORTATION OF DANGEROUS GOOD CLASSIFICATION:**
Oxidizing Solid, n.o.s. (Calcium Peroxide), Class 5.1, PG II, UN1479
- WHMIS CLASSIFICATION:**
Oxidizer
2. **COMPOSITION/INFORMATION ON INGREDIENTS**
- | Ingredients | Chemical Formula | CAS No. | Percentage |
|---|---|------------|------------|
| Calcium Peroxide | CaO ₂ | 1305-79-9 | 45%-70% |
| Calcium Hydroxide | Ca(OH) ₂ | 1305-62-0 | 10%-20% |
| Sodium, Calcium Aluminosilicate, Hydrated | Ca ₂ (Na,K) ₂ Al ₄ Si ₂₈ O ₇₂ 24H ₂ O | 12173-10-3 | 20%-30% |

Please see Figure 3, Oxygen Release Compounds, Comparative Rates of Oxygen Delivery (referenced from Adventus Website 3/9/07). You see in this graph that EHC-O is shown to have the same release profile, in terms of pounds of oxygen released over time, as that of simple calcium peroxide. However, the manufacturer clearly establishes in the MSDS that the EHC-O product is simple calcium peroxide plus 20%-30% filler. So it is difficult to understand how a product diluted by 20%-30% can release the same mass of oxygen as an un-diluted product. This appears to be little more than enthusiastic marketing.

Figure 3. Oxygen Release Compounds – Comparative Rates of Oxygen Delivery



Early Release of Oxygen from EHC-O is Wasted:

Rapid oxygen release exceeds saturation and bubbles out to the atmosphere

A recent statement made by a salesman for EHC-O that was disseminated on the bioremediation “list serve” chat group BioGroup (<http://www.bioremediationgroup.org/>) stated, “EHC-O releases between 80% and 90% of its content within 120 days”. Judging from the oxygen release profile curves published by the EHC-O manufacturer in previous figure 3, the fact is that the EHC-O releases 80% of its oxygen within the first 70 days, and in fact 50% of the available oxygen is liberated in the 21 days! Thus, while this “within 120 day” longevity claim is not a falsehood, it appears the purpose is to mislead the reader into thinking the longevity is greater than it really is.

When injected into groundwater to stimulate *in situ* bioremediation, the majority of oxygen to be released by EHC-O occurs within the first weeks’ time. It is very difficult to understand how this oxygen can diffuse outward significantly to stimulate microbial degradation within any meaningful volume of the aquifer as oxygen diffusion rates are limited in most aquifer settings². Instead, the dissolved oxygen concentration would most

² Cleary, R. W., and M.J. Unga, 1978: Analytical Method for Groundwater Pollution and Hydrology, Water Resources Program Report: 78-WR-15, Department of Civil Engineering, Princeton University, Princeton, New Jersey.

likely build up in the area of the product injection until it exceeds its solubility in the groundwater, at which point it would simply bubble out of the aquifer into the atmosphere above. This is simple, straight forward, well documented physical chemistry.

Short Longevity means Increased Application Costs:

EHC-O requires 3 to 4 applications to match ORC/ORC Advanced release in groundwater

The successful treatment of hydrocarbon contamination in groundwater requires one to treat not only the small fraction of hydrocarbon dissolved in the water itself, but also to treat the pollutant mass bound to the aquifer matrix which will ultimately dissolve into the groundwater. While chemical compounds that release oxygen can be used to stimulate biodegradation of both dissolved pollutants and the directly accessible portion of the mass of pollutants bound to the aquifer matrix, treating a meaningful portion of the bound hydrocarbons takes time.

Hydrocarbons bound to the subsurface aquifer material are not all bio-available. They must desorb from the matrix to be accessible for bioremediation. This requirement is well documented. The lack of fully treating the sorbed mass shows up in the form of contaminant “rebound” in water samples. **Any experienced practitioner of bioremediation knows that successful *in situ* bioremediation requires a minimum of about 12 months of oxygen supply to the aquifer to allow for desorption and biodegradation of hydrocarbon contaminants.**

The manufacturer of EHC-O acknowledges that EHC-O requires re-application at least every 90 days (at least quarterly). Figure 4 presents an excerpt from a proposal by Adventus that clearly states the requirement for quarterly re-application of EHC-O. This is a direct result of the fact that the majority of the oxygen released from EHC-O does so in a burst within the first weeks of application, with much of this escaping to the atmosphere as waste. Again, according to data provided by the manufacturer and presented in Figure 1 and Figure 3, after about two months close to 80% of the oxygen is already released. Without re-application at the three month point it is difficult to imagine that any significant contaminant biodegradation would occur within the aquifer.

Figure 4. EHC-O™ Proposal Excerpt - 90 Day Re-application



EHC-O Cost Estimate

REMEDIAL DESIGN

The Site has a 4-inch diameter monitoring well with low levels of petroleum hydrocarbons. The screened interval is 8-ft.

The organic COIs are degraded biologically under aerobic conditions. To facilitate *in situ* aerobic biodegradation of COI multiple socks containing EHC-O controlled-release oxygen source + inorganic nutrients will be placed into the monitoring well at quarterly intervals. The stainless steel canisters and EHC-O socks come preassembled in three-foot sections; each 3-foot section of 3-inch diameter sock (for a 4-inch well) contains about 6.5 lbs of EHC-O. Accounting for connections and spacing between canisters, two, 3-foot sections of EHC-O canisters + socks can be emplaced inside this monitoring well yielding a total of two, 4-inch diameter three-foot canisters (about 13 lbs of EHC-O).

The stainless steel canisters are re-used; the EHC-O sock insert can be exchanged quarterly over a one-year period. If subsequent monitoring allows for treatment modification, the frequency of sock replacement may be changed in an effort to reduce treatment costs.

The cost for EHC-O canisters and related hardware is presented below (Table 2) The hardware costs of the stainless steel EHC-O canisters to support the permeable sock represent a one-time capital cost. Subsequent replacement costs only include EHC-O sleeves.

Table 2. EHC-O sock and canister emplacement costs.

ITEM	4-Inch Diameter Units
3.04 gauge Canisters (stainless steel) and hardware; 3 ft sections	2 units
Canister unit price (3 ft section)*	\$175
a. EHC-O canister cost	\$ 350
EHC-O (3-ft sleeves)	2 units / qtr ←
EHC-O (3-ft sleeves) unit cost	\$160
b. EHC-O cost	\$ 480
c. Material Delivery (estimated)***	\$ 100
Total (a + b + c)	\$ 930

*One time cost; canisters can be re-used for subsequent applications;

** Any applicable taxes are not included.

*** Billed at cost plus 8%.

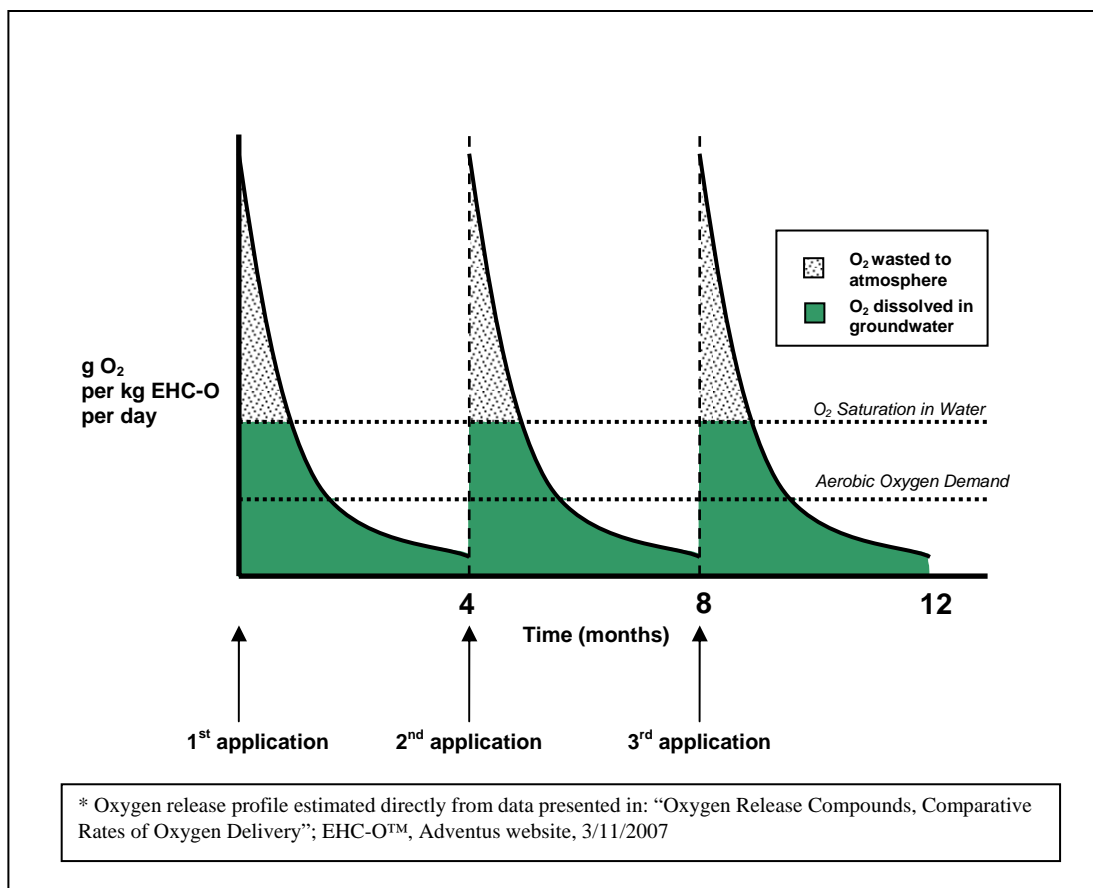
AAI's costs presented above include EHC-O materials plus delivery. These costs do not include remedial construction or services. These costs are valid for 30 days.

EHC-O Requires Re-injection: Expensive Product Costs/ Application Costs

The requirement for quarterly re-injection of EHC-O makes the use of this product very expensive compared to ORC/ORC Advanced. In order to provide a continuous release of oxygen to a hydrocarbon contaminated aquifer for a period of 9 to 12 months, one would be required to apply EHC-O at least 3 if not 4 times. Even applying EHC-O at this rate, the amount of oxygen that would be available within the aquifer is in question, as the rate of release from each injection would probably exceed solubility and force the evolution of the oxygen from solution into the atmosphere as waste upon each injection. One can easily estimate that after injection in a slow moving aquifer setting that as much as 30% to 50% of the oxygen generated by EHC-O would build up in the groundwater around the injection point, exceed saturation and bubble out of the groundwater.

Figure 5 shows the relative efficiencies of treating a groundwater plume with ORC or ORC Advanced versus EHC-O. Under this very typical scenario, the use of EHC-O would require three injections (if not four injections). The same project could be accomplished with one injection of ORC or ORC Advanced. Note that this comparison assumes that each re-application of EHC-O is conducted in an untreated area of the site. This is required because, unlike with the use of ORC or ORC Advanced, the short period of oxygen release of the EHC-O will not allow for significant oxygen dispersion from an injection point. Instead much of the rapidly released oxygen will simply bubble out of solution. If one were to use a single initial installation of reinjectable points to avoid the re-application drilling costs of using EHC-O, then the re-injection points would have to be on much closer spacing than with ORC or ORC Advanced; on the order of 3-4 times the number of points in the same area to ensure coverage due to low oxygen travel distances associated with EHC-O's short longevity.

Figure 5. Possible EHC-O™ Oxygen Release Profiles in Groundwater



Comparative costs of using ORC Advanced versus EHC-O are presented below in Table 2. This assumes that a site to be treated requires 1000 pounds of oxygen to be delivered. Note that while the theoretical material mass required for ORC-A and EHC-O are 5,882 lbs and 7,143 lbs respectively, this is simply not realistic. Because of the rapid oxygen release associated with EHC-O much of the oxygen does not stay in the water, thus requiring quarterly re-injection as mentioned above. In the EHC-O Realistic Scenario shown in Table 2, the material quantity for EHC-O is 14,285 lbs compared to 5,882 lbs for ORC Advanced. This assumes that the second and third injection of EHC-O use 50% of the initial requirement and that a fourth injection is not required (this is being very fair to EHC-O!). Under this fair and very realistic scenario, the true total application cost of using the EHC-O is \$94,043 versus \$57,840 for ORC Advanced.

Table 2. ORC Advanced® and EHC-O™ Cost Comparison Scenarios

Comparative Application Costs for ORC-A versus EHC-O Under Probably Scenario

Assumes realistic scenario of EHC-O oxygen loss from groundwater requiring additional mass of material

1	2	3	4	5	6	7	8	9	10	11	12	13	14	16
Technology	Required O ₂ in lbs.	O ₂ produced per lb. of material	lbs of material required assuming 100% distribution and utilization	Material Cost (\$/lbs.)	Theoretical Material Cost (assuming 100% distribution and utilization)	Single Application Expected O ₂ Release Profile	Number of Application Events Required (based on need for a minimum of 9 months O ₂ delivery)	Pounds of material delivered in application event #1	Pounds of material delivered in application event #2	Pounds of material delivered in application event #3	Realistic material quantity required for all applications	Total Material Cost (Column 5 x Column 12)	Injection equipment mob/demob* costs = \$2500 per event	True Total Project Cost = Column 13 + 14 + 15
ORC-A	1,000	0.17	5882	7.75	\$45,585	9-12 months	1 event = 2 days	5882	Not required	Not required	5,882	\$45,586	\$12,254	\$57,840
EHC-O Realistic Scenario	1,000	0.14	7143	4.5	\$32,144	3-4 months	3 separate events = 6 days	7143	3571 (assume 50% of original)	3571 (assume 50% of original)	14,285	\$64,283	\$29,760	\$94,043
EHC-O Improbable 100% efficient scenario	1,000	0.14	7143	4.5	\$32,144	3-4 months	3 separate events = 6 days	2381 (1/3 of theoretical)	2382 (1/3 of theoretical)	2383 (1/3 of theoretical)	7,143	\$32,144	\$29,760	\$61,904

* Assumed injection costs: 8 lbs./foot; 10 foot treatment thickness; 15 points per day; \$2500/day

It is important to note that if one were to assume the highly unlikely scenario (many would say impossible scenario) of all of the EHC-O oxygen released staying in the groundwater (without bubbling out) and evenly distributing out across the site, the use of ORC Advanced is still lower in cost! This is clearly depicted in the EHC-O Improbable 100% Efficient Scenario shown in Table 2 where the true total project cost is \$61,904 versus \$57,840. These cost comparisons do not reflect the additional field cost of the engineering firm managing the site activities. Due to the increased oversight required to implement EHC-O injections three times, the actual costs of implementing EHC-O would be even higher than what is already illustrated in Table 2!

pH buffering comparison to ORC/ORC Advanced is false:

ORC/ORC Advanced employs a classic mono/dibasic potassium phosphate buffer system

It appears that Adventus, in an effort to show that EHC-O has superior performance over ORC or ORC Advanced in some category chose to focus on buffering capacity and nutrient level. Oddly however, is the fact that the presence of a buffer and nutrients in ORC and ORC Advanced is widely known, published in the respective MSDS and published in the ORC and ORC Advanced patent.

Figure 6 shows a comparison of EHC-O and “Market-leading oxygen releasing products” – an obvious reference to ORC and ORC Advanced. The chart states a comparison of “Buffering Capacity in Product”. This information is simply false.

Figure 6. Product Nutrient Content and Buffering Capacity Reference



EHC-O Cost Estimate

Table 1. Comparison of price and performance of EHC-O versus market-leading oxygen releasing products

Product Description	Price (\$US/lb)	Nutrients in Product	Buffering Capacity in Product
EHC-O	4.50	Yes	Yes
Calcium-based	7.00 to 8.00	No	No
Magnesium-based	7.50 to 11.00	No	No

ORC and ORC Advanced employ the monobasic/dibasic potassium phosphate buffer system. This is the classic buffer system taught in every university freshman chemistry course and used widely around the world. When the manufacturers of EHC-O were putting together their marketing materials, it seems that Regenesis’ use of this buffer was overlooked, even though it is clearly posted on most of the ORC and ORC Advanced technical materials and included in the ORC and ORC Advanced patent.

(Note, as a practical matter, the inclusion of a buffer is really not necessary in the vast majority of groundwater applications as most aquifer materials have considerable buffering capacity).

Nutrient comparison to ORC/ORC-A is false: ORC and ORC Advanced contain significant levels of phosphorus, a key nutrient

Figure 6, as mentioned above, is a comparison of EHC-O and “Market-leading oxygen releasing products” – a reference to ORC/ORC Advanced. The chart states a comparison of “nutrients in product”. This information is false.

When considering the growth of microorganisms in the subsurface it is generally acknowledged by microbial ecologists that the key requirements are for a carbon source (the contaminant) an electron acceptor (oxygen), nitrogen and phosphorus. The nitrogen and phosphorus are considered the main nutrients that can come into short supply and limit microbial growth in the subsurface. Regenesis, when choosing a buffer system to add to the product chose the mono/dibasic phosphate buffer system specifically to allow for the supply of phosphorus to the stimulated microbial population. When the manufacturers of EHC-O were putting together their marketing materials, it seems that once again, this point was overlooked even though it is clearly posted on most of the ORC and ORC Advanced technical materials and patent. There is no indication in the literature provided by Adventus that EHC-O contains either of the key nutrients nitrogen or phosphorus.

Closing

ORC and ORC Advanced are products developed with patented technology specifically to maximize the rates of *in situ* groundwater bioremediation of hydrocarbon contaminants. These products have been technically proven, validated as cost effective by over one hundred presentations and publications (many by third parties) and by the successful use of these products on over 14,000 sites world-wide.

EHC-O is a blend of typical calcium peroxide with 20% to 30% filler material added. It has an oxygen release profile typical of commodity calcium peroxide. EHC-O is being heavily marketed by Adventus directly against Regenesis' products. The claims being made about the product in reference to ORC and ORC Advanced are not technically credible. As to whether or not the product claims by Adventus are being ethically represented to engineering firms and their clients- this is left to the reader to decide.

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