

Hyperbaric Oxygen Therapy and Flammability of Topical Skin Care Products

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Abstract

Product selection may determine whether or not proper skin care can be safely provided during hyperbaric oxygen therapy. Independent studies were conducted comparing the oxygen compatibility for six leading skin care products currently on the market. Oxygen compatibility was determined via autogenous ignition temperature (AIT) testing, oxygen index (OI) testing and heat of combustion (HoC) testing. AIT is a relative indication of a material's propensity for ignition, OI is a relative indication of a material's flammability, and HoC is the absolute value of a material's energy release upon burning. Products with a high AIT, a high OI and a low HoC are recognized as being more compatible for application in oxygen-enriched environments. Furthermore, an Acceptability Index based on the above factors is used to rank overall oxygen compatibility. By way of example, the HoC value of Aquaphor Healing Ointment® from Beiersdorf AG, was

more than five times greater than Remedy Skin Repair Cream™ from Medline Industries, Inc. Subsequently, Skin Repair Cream™ received an Acceptability Index rating approximately 25 times better than Aquaphor®. Additional skin care products included in the study were Aloe Vesta 2-in-1 Protective Ointment Skin Protectant® from Convatec, Remedy Calazime Protectant Paste® from Medline Industries Inc., Critic Aid Clear Moisture Barrier Ointment® from Coloplast, Nutrashield Cream™ from Medline Industries, Inc. and Secura Protective Ointment® from Smith & Nephew. Application of flammable products during hyperbaric oxygen therapy imposes significant risks associated with ignition and is therefore strongly discouraged. Further studies are recommended to determine which products can provide proper skin protection and healing during hyperbaric oxygen therapy while maintaining strict fire safety standards.

Background

Hyperbaric oxygen therapy has been found useful in the treatment of wounds and wound infections^{1,2,3}. The therapy consists of 60-120 minute periods of breathing 100% oxygen in a chamber pressurized between 2.0-2.4 ATA⁴. Periodic breathing of high oxygen concentrations increases the transmission of oxygen into the wound. The arrival of excess oxygen stimulates the production of such oxidants as hydrogen peroxide. Oxidant production leads to increased growth factor levels, increased fibroblast collagen synthesis, increased neoangiogenesis, and increased bacterial phagocytosis^{5,6,7}.

Physiological risks associated with proper hyperbaric oxygen treatment remain minimal. Numerous studies confirm that hyperbaric chamber sessions do not cause adverse effects on platelet aggregation, platelet metabolism, erythrocyte or lymphocyte numbers, or

the antioxidant status of the plasma^{4,8,9}. In fact, hyperbaric oxygen therapy is increasingly used in pediatric medicine to safely treat neonates and children^{10,11}. However, there are significant external risks associated with the flammability in oxygen-enriched hyperbaric chambers.

Fire is catastrophic in the confined space of a hyperbaric chamber. A study published in 1997 found that 77 human fatalities have occurred in 35 hyperbaric chamber fires¹². Hyperbaric chamber fires are primarily caused by prohibited sources of ignition carried inside the chamber. Currently, clinical practice discourages the application of topical cosmetic or topical medical products prior to receiving hyperbaric oxygen therapy. The majority of topical products are flammable, including hair care products, beauty products and skin care products. In particular, skin care products are often composed

Background Continued

of petrolatum or petrolatum fractions such as paraffin. Petrolatum and petrolatum fractions are a semi-solid mixtures of hydrocarbons obtained by the fractional distillation of petroleum¹³. Hydrocarbon-oxygen mixtures are extremely explosive, especially in confined spaces^{14,15}. Flammability risks associated with certain topical products have prevented the use of even oxygen compatible skin care products during hyperbaric oxygen therapy.

Utilizing advanced water and silicone-based creams instead of petrolatum-based products diminishes risks associated with flammability. Water and silicone-based products that have undergone compatibility

testing for use in oxygen-enriched environments have attained promising results^{16,17}. In fact, selected silicone creams were found to be five times less combustible than popular petrolatum-based products¹⁸.

Silicone creams may provide a safe means of treating peri-wound skin during hyperbaric oxygen therapy. Silicones are currently used in numerous transdermal delivery systems, catheters and specialized medical devices^{19,20}. Providing proper skin protection and nutrition while stimulating wound oxidant production deserves consideration. Safely combining effective treatment methods may promote improved healing and wound closure.

Results

MATERIAL	AIT (°C)	HoC (CALORIES/GRAM)	OI (%)
Aloe Vesta 2-in-1 Protective Ointment Skin Protectant®	198	7735	30
Aquaphor Healing Ointment®	186	10869	25
Calazime Protectant Paste®	170	5915	25
Critic Aid Clear Moisture Barrier Ointment®	193	8879	21
Nutrashield Cream™	224	2111	55
Secura Protective Ointment®	205	10973	30
Skin Repair Cream™	179	1989	50

Table I. AIT indicates a material's propensity for ignition; HoC is an absolute value of a material's energy release upon burning; OI indicates a material's flammability. Oxygen compatible materials maintain high AITs, high OIs, and low HoC values¹⁶.

Figure I. AIT is a relative indication of a material's propensity for ignition. Materials with high AITs result in higher Acceptability Indices^{16,17,18}.

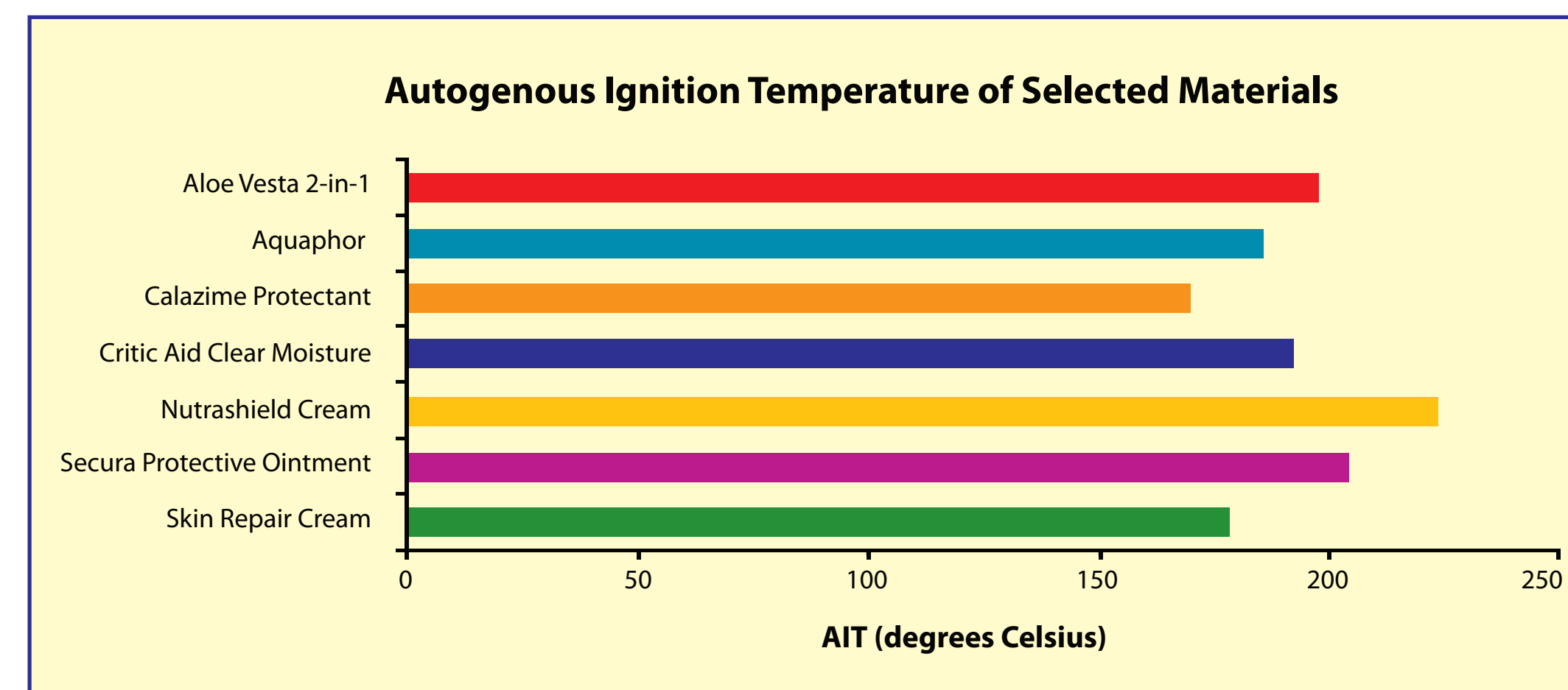


Figure II. HoC is an absolute value of a material's energy release upon burning, which is an indication of its damage potential. Materials with low HoC values result in higher Acceptability Indices^{16,17,18}.

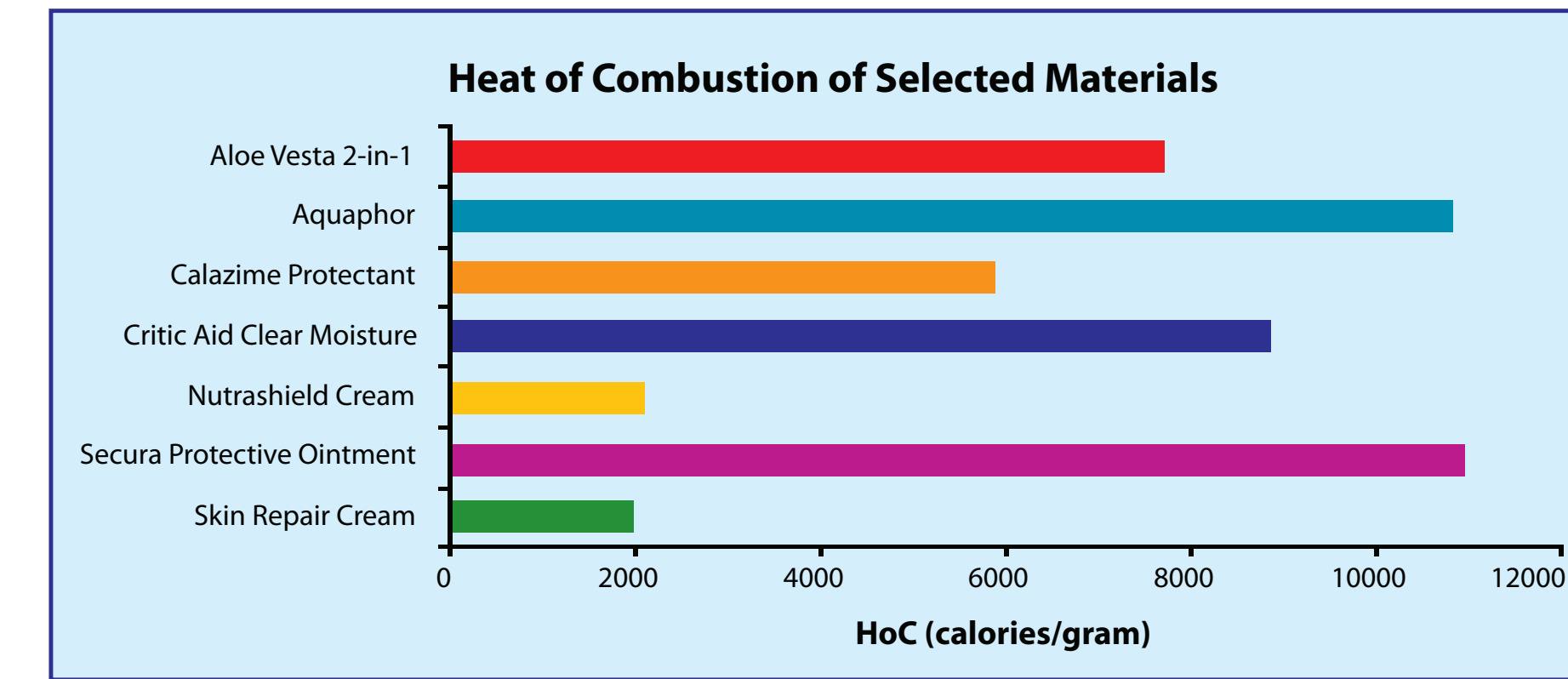


Figure III. OI is a relative indication of a material's flammability. Materials with high OIs result in higher Acceptability Indices^{16,17,18}.

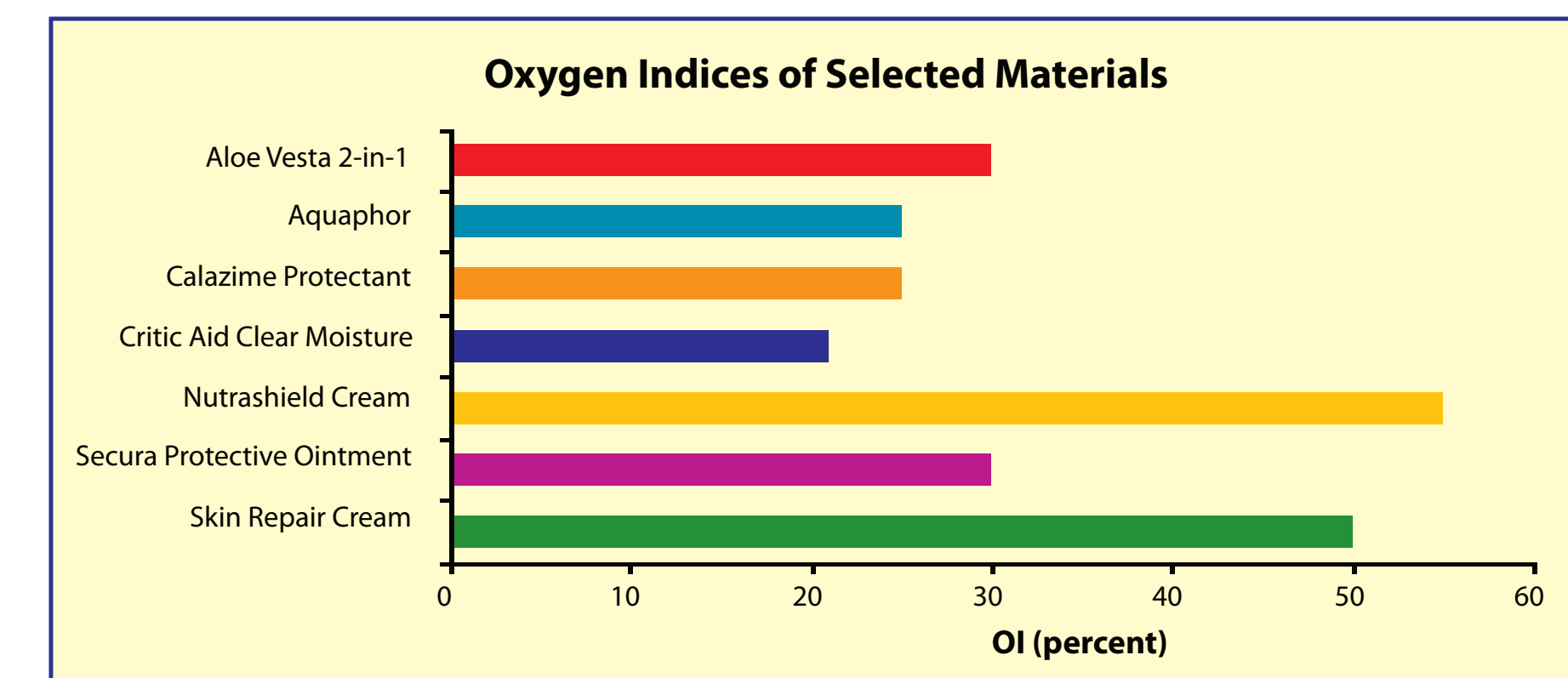
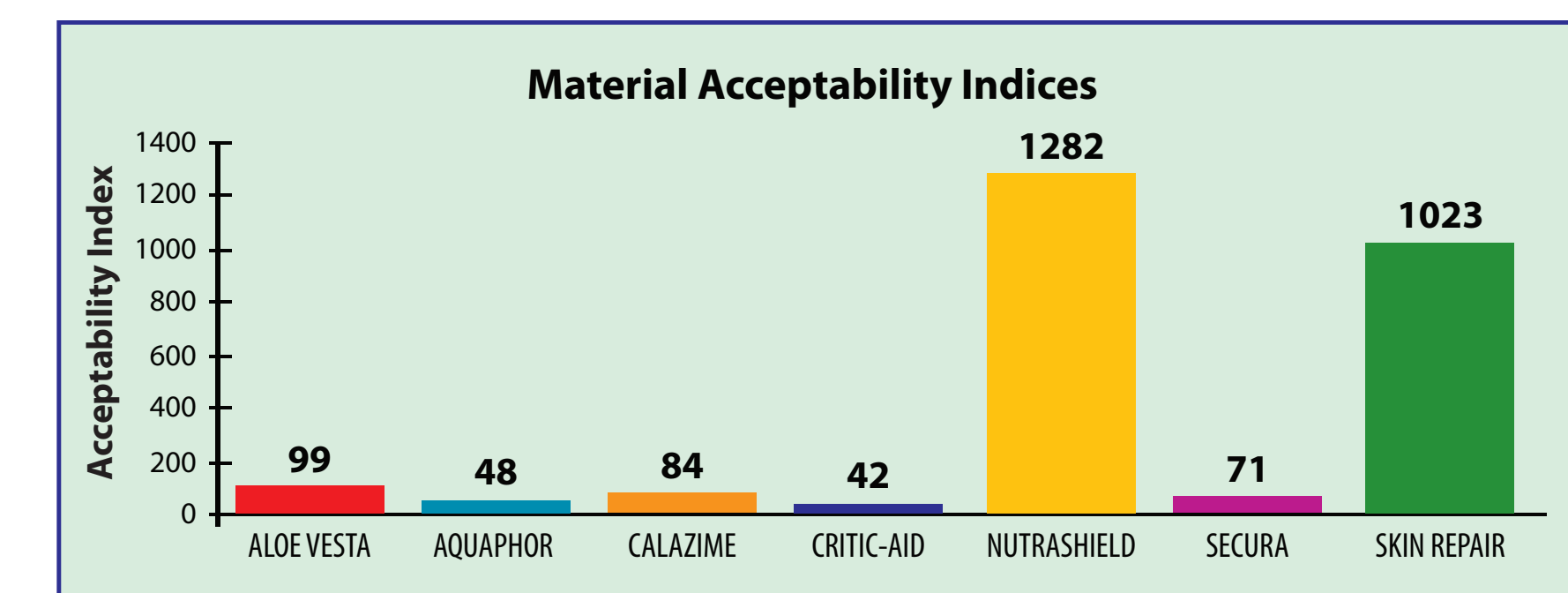


Figure IV. Acceptability Indices are used to rank the oxygen compatibility of various materials. The Index is based on the following equation^{16,17,18}: $[(OI)^2 \times (AIT)] / (HoC)$



Conclusions

The results displayed a wide range of AIT, HoC, and OI values, corresponding to significantly different Acceptability Indices. In particular, the HoC and OI values varied greatly among the seven skin care products tested. It seems that maintaining high OI values while preserving low HoC values is the characteristic most required for oxygen compatibility. During testing, a sustained fire was not achieved for Skin Repair Cream™. Although Skin Repair Cream™ achieved momentary flash-point behavior, the material would self-extinguish soon after the promoter flame was removed¹⁸. The water and silicone base of Skin

Repair Cream™ is most likely responsible for the product's self-extinguishing behavior. In contrast, the petrolatum, paraffin and/or mineral oil base of certain other products tested is likely to be responsible for the corresponding decrease in oxygen compatibility. Oxygen compatibility testing should be considered as an appropriate method of determining whether certain skin care products can be used safely and effectively during hyperbaric oxygen therapy. Further research concerning oxygen compatibility and product acceptability is suggested.

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