

Topical Products and Fire Safety in Neonate High Oxygen Environments

Abstract

Skin care product selection may be essential to improving fire safety in oxygen-enriched, neonatal environments. Independent studies were conducted comparing the oxygen compatibility of the industry standard, a petrolatum-based product, against newer silicone-based products. Oxygen compatibility was determined via autogenous ignition temperature testing, oxygen index testing and heat of combustion testing. Autogenous ignition temperature is a relative indication of a material's propensity for ignition, oxygen index is a relative indication of a material's flammability, and heat of combustion is the absolute value of a material's energy release. Skin care products with a high autogenous ignition temperature, a high oxygen index and a low heat of combustion 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. The heat of combustion value of the industry standard, Aquaphor Healing Ointment® from Beiersdorf AG, was more than five times greater than silicone-based Nutrashield™ and Skin Repair Cream™ from Medline Industries. Aquaphor® had a heat of combustion value of 10869 calories/gram, ranking near gasoline at 10400 cal/g and mineral oil at 10930 cal/g. Subsequently, Skin Repair Cream™ and Nutrashield™ received an Acceptability Index rating approximately 20 times and 25 times better than Aquaphor®, respectively. The application of flammable, petrolatum-based products in neonatal intensive care environments enriched with 23-100% oxygen may impose significant risks associated with ignition and fire. Further studies are recommended to determine which products can provide proper neonatal skin care while maintaining fire safety standards.

Background

Table I. Enclosure systems combine oxygen to obtain the oxygen saturation required for infant survival. The system provides an enriched oxygen atmosphere with an oxygen concentration most commonly between 23-90%, although the system is capable of achieving concentrations of 100%⁷. Application of petrolatum-based products containing highly flammable hydrocarbons may endanger infants being treated in confined neonatal enclosure systems.

AIR FLOW (L/min)	OXYGEN FLOW (L/min)	PERCENT OXYGEN IN ENCLOSURE SYSTEM (%)
9	1	30
8	2	40
6	4	50
5	5	60
4	6	70
2.5	7.5	80
1	9	90

Table II. Two of the most common endotracheal tube materials are polyvinylchloride and red rubber. Both materials have surprisingly low indices of flammability. The low indices in conjunction with petrolatum-based product application may impose significant risks in neonatal intensive care units. Endotracheal tubes are utilized in low-flow, high-flow and reservoir systems¹¹.

ENDOTRACHEAL TUBE MATERIAL	INDEX OF FLAMMABILITY
POLYVINYLCHLORIDE	0.263
RED RUBBER	0.176

Results

Table III. Autogenous ignition temperature indicates a substance's propensity for ignition; oxygen index indicates a substance's flammability; heat of combustion is an absolute value of a material's energy release upon burning. Oxygen compatible Nutrashield™ and Skin Repair Cream™ maintain a high autogenous ignition temperature and oxygen index, and a low heat of combustion¹⁷.

MATERIAL	AUTOGENOUS IGNITION TEMP (°C)	OXYGEN INDEX (%)	HEAT OF COMBUSTION (CALORIES/GRAM)
Aquaphor®	186	25	10869
Nutrashield™	224	55	2111
Skin Repair Cream™	179	50	1989

Figure I. The Acceptability Index is used to rank oxygen compatibility based on the following equation:

$$\frac{[(\text{oxygen index})^2 \times (\text{autogenous ignition temperature})]}{(\text{heat of combustion})}$$

Silicone-based skin care products received substantially higher Acceptability Indices than petrolatum-based products¹⁸. In particular, petrolatum-based Aquaphor® burns with an extremely high energy release, comparable with gasoline¹⁹.

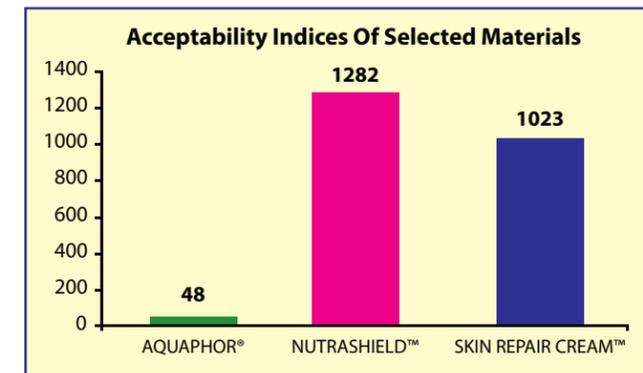
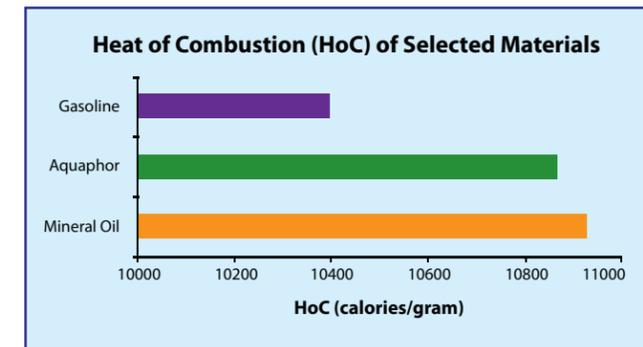


Figure II. Heat of combustion is an absolute value of a material's energy release upon burning, which is an indication of its damage potential. Petrolatum-based Aquaphor® was found to have a heat of combustion greater than gasoline. Furthermore, Aquaphor® contains mineral oil, which was also found to release more energy upon burning than gasoline¹⁹.

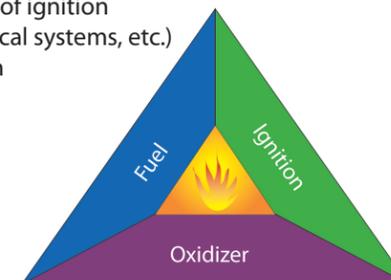


Discussion

The application of petrolatum-based products to neonatal skin in oxygen-enriched environments may impose significant fire risks. However, introducing highly ignitable and extremely flammable petrolatum materials into infant care systems is avoidable. New silicone technologies allow for oxygen compatible products that provide proper neonatal skin care while diminishing risks associated with fire safety.

Each of the following components is considered necessary for combustion to occur under standard conditions. Reducing or eliminating one or more of the components may diminish fire risks²⁰.

- Presence of burnable material (petrolatum, etc.)
- Source of ignition (electrical systems, etc.)
- Oxygen



Conclusions

The heat of combustion value of the petrolatum-based product tested was more than five times greater than the silicone-based products tested. The petrolatum-based product had a heat of combustion value of 10869 calories/gram, ranking in between gasoline (10400 cal/g) and mineral oil (10930 cal/g). However, the manufacturer of the chosen petrolatum-based product may indeed offer an alternative skin care product that is oxygen compatible. The silicone-based products tested were determined to be highly compatible with oxygen-enriched environments. The chosen silicone-based products achieved Acceptability Index Indices of 1282 and 1023, respectively. Additional studies are recommended to determine which products can provide proper neonatal skin care while maintaining strict fire safety standards.