



Determining the quality of hydrophobic barrier creams by rheological measurements, sensory analysis, pH determination and permeation time measurements

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ABSTRACT

The aim of this work was to investigate how rheological measurements, sensory analysis, determination pH, and the measurement of permeation time could help to determine quality of waterproof barrier creams which are used in healthcare.

Rheological properties, permeation time, pH, sensory evaluation stability on both commercial hydrophobic barrier creams and own recipe creams were investigated. The presence of mere hydrophobic components in a hydrophobic barrier cream recipe ensures high skin protection against water and aqueous solutions of detergents in working environment. In other cases, the cream is a mere supplement in the prevention of skin diseases by ensuring proper skin hydration after work. Conducting a set of analysis for barrier creams and defining the connection between physical parameters of the cream and their barrier properties allow to control their quality at the manufacturing stage and to modify existing recipes. Hence, it is possible to prevent occupational skin diseases such as ICD and not only treating their consequences. This helps improve the quality of life of people working with harmful and irritating substances and healthcare services.

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1. Introduction

Human skin has natural properties protecting it from harmful external chemical or physical factors, bacteria or mechanical injuries.

The stratum corneum can grow and regenerate. Elastic and collagen fibers provide elasticity and extensibility, whereas the adipose tissue attenuates mechanical injuries.

Acid pH of the epidermis surface and alkaline pH of deeper cells layers create electrostatic forces that block the penetration of chemical compounds into the skin. Corneous cells layer at the surface has electric resistance which decreases as we sweat.

The formation of melanin and urocanic acid protects the body from ultraviolet radiation, as well as against heat and cold.

Langerhans cells located in the epidermis strengthen the immune system, by releasing mediators which activate the immune defense, so the skin is an effective barrier strengthening and supporting the immune system of the body.

Keratinocytes located under the corneous layer constitute a protective barrier against water lost from the body. Excessive hydration impairs skin's defenses against the penetration of chemicals and contributes to the development of bacterial flora.

Embrittlement of skin's defenses by chemical agents (irritating or allergene), physical, biological or mechanical factors or due to the diminution of general body defenses results in the development of occupational skin diseases [1].

Despite the belief that the factors of exposure to occupational skin diseases are fairly well known and it is possible to use different skin prevention measures, the increase in the number of occupational skin diseases in the EU countries is worrying (skin diseases are ranked 2nd most common occupational diseases after musculoskeletal disorders) [2,3].

According to the Nofer Institute of Occupational Medicine, the average annual incidence of dermatitis in Poland is 8 [4].

It is believed to be caused by the malfunction of occupational health services, including diagnostic centers. Also employees themselves tend to ignore benign dermatitis and sometimes hide the problem for fear of losing their jobs. Hence, the low average annual incidence of dermatitis is not due to different environmental conditions or lower susceptibility to allergies.

Skin protection measures aren't subject to certification. There is no evaluation of their quality conducted by the so called "third party". It

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is only possible to rely on the information given by producers — usually on packaging or on the web site [5].

Moreover, literature data showing that barrier creams prove less effective than declared by the manufacturer imply that it is necessary to look for new recipes and new universal and objective in vitro analysis methods. These methods should be able to determine barrier cream properties already at the production stage [5–8]. This would help prevent occupational skin diseases including ICD as prevention is crucial in skin protection.

It implies important workload and financial cost hence it is worth finding correlation between basic physical parameters and physical barrier cream properties, things that have been demonstrated in the present work.

2. Materials and methods

Waterproof barrier creams are applied to the skin. Actions related to this operation, such as collecting the product from the container, applying it to the skin, spreading and rubbing are traditionally evaluated by sensory methods.

Sensory analysis has several drawbacks. The evaluation is subjective and also time and money consuming. Evaluation from the sensory analysis can to some extent be replaced by the rheological characterization [9,10].

For this purpose, the measurement of the flow curve and viscosity is designated. This determines the structure of the formulation across the range of its application [11].

Randomized clinical tests of BCs are still missing for reasons of methodological difficulties, ethical doubts and the enormous expenditure for a test with respect to the preventive benefit of BCs in practice. Besides various in vitro methods, non-invasive biophysical measurements are of great importance, especially for clinical week reactions [12].

In Poland, test methods for hydrophobic skin protection were developed with the participation of the Central Institute for Labour Protection—National Research Institute (CIOP—PIB). Among them: indicator color change (permeation time for 5% water solution through thin layer of hydrophobic creams with indicator) and surveys (controlled application of the preparation and evaluation of its effectiveness in an appropriate period of time) [13,14].

To verify the possibility of using rheological measurements, sensory analysis, pH determination, permeation time to determine the quality of waterproof barrier creams the following steps were carried out:

- Ingredients of six preparations available on the market (manufactured in UE), declared as skin protecting were analyzed. The composition declared in INCI (International Nomenclature Cosmetic Ingredients) of the hydrophobic barrier creams is specified in Table 1.
- Hydrophobic barrier creams containing only hydrophobic substances were obtained. Cream formulation is presented in Table 2.
- To confirm the protective nature of the preparation (available on the market and according to own recipe) the study of their miscibility with water, oil and detergents was conducted. 2 g of the cream is weighted and placed on watch glass. To each sample were added drops of water, oil or aqueous detergents. Samples were mixed and their homogeneity evaluated.
- pH measurement was performed according to PN-93/C- 04842 by A. Posted pH meter HANNA HI 221. The measurement was repeated three times, and an average value was calculated.
- Quality testing: permeation time was analyzed. This study was conducted based on indicator color change method (CIOP—PIB method). A sample of the cream was mixed with an indicator (phenolphthalein or methyl orange). The sample solution has been applied. The time until the 3 points discolored [13,14] was measured. Time (in min) after the change of the color was observed, indicating the cream's efficacy. The longer the time the better the barrier properties of the cream.

Table 1

Composition of hydrophobic barrier creams available on the market.

Product	Declared properties	Ingredients INCI
A	Protects skin against water and aqueous solutions of surfactants acids up to 5% alkalis up to 5% and salts.	Cera alba, stearic acid, Paraffinum Liquidum, zinc oxide
B	Barrier cream is a special preparation for care of allergic, destroyed skin with allergic and non-allergic contact changes. It perfectly protects from the influence of the external factors (i.e. detergents, irritants), regenerates micro abrasions of the epidermis, soothes irritations and prevents new changes. It strengthens the skin's resistance and stimulates renewal of the epidermis.	Aqua, glycerin, Isopropyl Palmitate, Perfluoropolymethylisopropyl Ether, Cetearyl alcohol, Paraffinum Liquidum, stearic acid, Caprylic/capric Triglyceride, Glyceryl Stearate, Canola oil, PVP/eicosene Copolymer, Cyclopentasiloxane, Polysorbate 60, butylene glycol, <i>Tephrosia purpurea</i> seed extract, Allantoin, Hydroxypropyl Starch Phosphate, Cyclohexasiloxane, phenoxyethanol, Butylparaben, propylparaben, Ethylparaben, Methylparaben, Triethanolamine, Disodium EDTA, PEG-8, Tocopherol, Ascorbic Acid, Ascorbyl Palmitate, citric acid
C	Skin protection cream with an innovative formulation concept (W/O/W emulsion). It toughens the natural skin barrier and effectively protects the skin where there is frequent contact with water or water-based workplace substances (water-based cooling lubricants, water based solutions of dyestuffs, acids, alkaline solutions, salts, cleaning agents and disinfectants, cement, lime and fertilizers), as well as when wearing occlusive protective clothing.	Aqua, Paraffinum Liquidum, Isopropyl Palmitate, Cetearyl alcohol, Polyglyceryl-2-Dipolyhydroxystearate, Propylene Glycol, cetearyl glucoside, C12-15 Alkyl Benzoate, stearic acid, Bisabolol, Petrolatum, <i>Hamamelis virginiana</i> Water, PEG-30 Dipolyhydroxystearate, PEG-40 Stearate, Methylparaben, propylparaben, Ethylparaben, Isobutylparaben, Butylparaben, Ethanol
D	Highly-effective skin care cream for extremely stressed and very dry skin. regenerative W/O emulsion with high lipid level, intensively lipid-replenishing, also recommended as concomitant skin care for the therapy of irritated skin, silicone-free, perfumed.	Aqua, Paraffinum Liquidum, PEG-7 Hydrogenated Castor Oil, Isopropyl Myristate, Petrolatum, sorbitol, PEG-45/Dodecyl Glycol Copolymer, Sodium Lactate (and) lactic acid, lanolin, Sorbitan Isostearate, PEG-2 Hydrogenated Castor Oil, Ozokerite, Hydrogenated Castor Oil, magnesium sulfate, Imidazolidinyl Urea, sorbic acid, lecithin, Propylene Glycol, BHT, Glyceryl Stearate, Ascorbyl Palmitate, citric acid, Parfum, Benzyl Salicylate, Citral, Citronellol, Geraniol Hydroxycitronellal, Isoeugenol Limonene, Linalool, Alpha-Isomethylionone, Cinnamyl Alcohol
E	Barrier cream against chemical substances soluble in water. Protecting the skin from water solutions and industrial water-soluble substances.	Aqua, mineral oil, glycerin, Ethylhexyl Stearate, PEG-7 Hydrogenated Castor Oil, Caprylic/capric Triglycerides, Dibutyl Adipate, PEG-45/Dodecyl Glycol Copolymer, cera alba, stearyl alcohol, panthenol, magnesium stearate, Aluminum Stearate, Tocopheryl Acetate, Parfum, phenoxyethanol, Methylparaben, Ethylparaben, propylparaben, Butylparaben
F	Skin protection cream with dualistic effect in case of skin exposure to not clearly defined or varying, water-soluble or water-insoluble substances. With waxes and special film-forming substances. Quickly absorbed, without mineral oil, silicone-free, perfumed or fragrance-free.	Aqua, C12-15 Alkyl Benzoate, Isopropyl Palmitate, Zinc Stearate, Myristyl Myristate, Cetearyl alcohol, cetearyl glucoside, Cocoglycerides, Shorea Stenoptera Butter, cera alba, Methyl Hydroxyethylcellulose, stearic acid, Carrageenan, <i>Helianthus annuus</i> Seed Oil, Butyrospermum Parkii Butter, phenoxyethanol, Triethylene Glycol, Imidazolidinyl Urea, Methylparaben, Dehydroacetic Acid Parfum, potassium hydroxide, Tocopheryl Acetate

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