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Research of sunscreens with x-ray diffraction and UV-spectroscopy

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Abstract

X-ray scattering/diffraction is one of the most popular methods for studying colloidal (emulsions) systems. This method allows measuring the interplane distance and gives information on structure: determines structure or analyses unknown structure.

In this work we investigate macrostructure sunscreens. We study their structural thermal behavior using small angle x-ray scattering/diffraction. We measure the UV–absorption and look for correlation between the structure and the UV–absorption.

1 SUNSCREEN THEORY

1 Sunscreen theory

Sunscreen (also known as sunblock or suntan lotion) is a lotion, spray or other topical product that helps protect the skin from the sun's ultraviolet (UV) radiation, and which reduces sunburn and other skin damage, with the goal of lowering your risk of skin cancer.

Sunscreens are effective in reducing sunburn, but not necessarily the risk of cancer.

Recently, there has been increased attention to the possibility of adverse health effects associated with the synthetic compounds in most sunscreens. Some sunscreens generate harmful compounds that might promote skin cancer.

The three commonly used ultraviolet (UV) filters - octylmethoxycinnamate, benzophenone 3 and octocrylene - eventually soak into the deeper layers of the skin after their application, leaving the top skin layers vulnerable to sun damage.

The most effective sunscreens protect against both UVB (ultraviolet radiation with wavelength between 290 and 320 nanometres), which can cause sunburn, and UVA (between 320 and 400 nanometres), which damages the skin with more long-term effects, such as premature skin aging.

1.1 Mechanism of action

The principal ingredients in sunscreens are usually aromatic molecules conjugated with carbonyl groups. This general structure allows the molecule to absorb high-energy ultraviolet rays and release the energy as lower-energy rays, thereby preventing the skin-damaging ultraviolet rays from reaching the skin. So, upon exposure to UV light, most of the ingredients (with the notable exception of avobenzone) do not undergo significant chemical change, allowing these ingredients to retain the UV-absorbing potency without significant photo-degradation.

Most sunscreens work by containing either an organic chemical compound that absorbs ultraviolet light (such as oxybenzone) or an opaque material that reflects light (such as titanium dioxide, zinc oxide), or a combination of both. Typically, absorptive materials are referred to as chemical blocks, whereas opaque materials are mineral or physical blocks.

1.2 Sun protection factor

All sunscreens differ in the SPF factor.

The SPF of a sunscreen is a laboratory measure of the effectiveness of the sunscreen; the higher the SPF, the more protection a sunscreen offers against UV-B (the ultraviolet radiation that causes sunburn). The SPF indicates the time a person can be exposed to sunlight before getting sunburn with a sunscreen applied relative to the time they can be exposed without sunscreen. In practice, the protection given by a particular sunscreen depends on factors such as:

- The skin type of the user.
- The amount applied and frequency of re-application.
- Activities in which one engages (for example, swimming leads to a loss of sunscreen from the skin).
- Amount of sunscreen the skin has absorbed.

Dosing for sunscreen can be calculated using the formula for body surface area and subsequently subtracting the area covered by clothing that provides effective UV protection. The dose used in FDA (Food Drug Administration) sunscreen testing is 2 mg/cm^2. Contrary to the common advice that sunscreen should be reapplied every 2–3 hours, the best protection is achieved by application 15–30 minutes before exposure, followed by one reapplication 15–30 minutes after the sun exposure begins. Further reapplication is only necessary after activities such as swimming, sweating, and rubbing. Sunscreen needs to be reapplied within 2 hours in order to remain effective. Not reapplying could even cause more cell damage than not using sunscreen at all, due to the release of extra free radicals from absorbed chemicals.

The SPF is an imperfect measure of skin damage because invisible damage and skin aging is also caused by the very common ultraviolet type A, which does not cause reddening or pain. Conventional sunscreen does not block UVA as effectively as it does UVB, and an SPF rating of 30+ may translate to significantly lower levels of UVA protection .UVA also causes DNA damage to cells deep within the skin, increasing the risk of malignant melanomas. Even some products labelled "broad-spectrum UVA/UVB protection" do not provide good protection against UVA rays. The best UVA protection is provided by products that contain zinc oxide, avobenzone, and mexoryl. Titanium dioxide probably gives good protection, but does not completely cover the entire UV-A spectrum.

Mathematically, the SPF is calculated from measured data as:

$$\mathrm{SPF} = \frac{\int A(\lambda)E(\lambda)d\lambda}{\int A(\lambda)E(\lambda)/\mathrm{MPF}(\lambda)\,d\lambda},$$

- where $E(\lambda)$ is the solar irradiance spectrum,
- $A(\lambda)$ the erythemal action spectrum, and $\mathrm{MPF}(\lambda)$ the monochromatic protection factor, all functions of the wavelength λ.
- The MPF is roughly the inverse of the transmittance at a given wavelength.

The principal requirements of cosmetic sunscreens are:

1. UV-absorption range of maximum width
2. High specific absorption in this range
3. Photo- and thermostability
4. Compatibility with skin (no irritant or toxic effects on the skin)
5. Good skin feel and good adhesion to the skin
6. Resistance to water
7. Good compatibility with other cosmetic substances and good solubility in cosmetic solutions and preparations.

1.3 Possible adverse effects

Some individuals can have mild to moderate allergic reactions to certain ingredients in sunscreen, particularly the chemical benzophenone, which is also known as phenyl ketone, diphenyl ketone, or benzoylbenzene. It is not clear how much of benzophenone is absorbed into the bloodstream, but trace amounts can be found in urinalysis after use. UV rays absorbed by the skin can generate harmful compounds called reactive oxygen species (ROS), which can cause skin cancer and premature aging. The researchers found that once the filters in sunscreen soak into the lower layers of skin, the filters react with UV light to create more damaging ROS. To reduce ROS generation and damage, the researchers recommend reapplying the sunscreen often, which will replenish the sunscreen which has penetrated the skin. Future possibilities may include the development of sunscreens which stay at the surface of the skin, or mixing sunscreens with antioxidants that can neutralize ROS.

2 SCATTERING THEORY

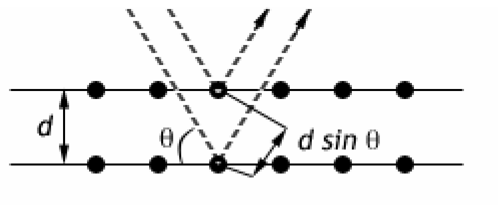
2.1 Scattering in general

When a visible photon (laser beam) hits a target its electrons are accelerated by the electrical field of the EM- wave. The accelerated electron works as a hertz' dipole and emits a secondary wave with the same frequency as the stimulating primary-wave. Works for weakly bound that means weakly damped electrons as for example valence- electrons. As we analyze samples with more than one electron the secondary waves interfere to give a scattering pattern. The scattering is sensitive to structures that are in the same regime as the used wavelength. That means for a laser you can analyse structures in the nm regime, as for example caused by emulsions systems.

2.2 Mechanism

X-ray scattering is based on the ***Bragg's law.***

As the wave enters the crystal, some portion of it will be reflected by the first layer, while the rest will continue through to the second layer, where the process continues. By the definition of constructive interference, the separately reflected waves will remain in phase if the difference in the path length of each wave is equal to an integer multiple of the wavelength. In figure on the right, the path difference is given by $2d\sin\theta$, where *d* denotes the interplanar distance.



1) Diffraction Calculation

This gives the formula for what is known as the **Bragg condition** or **Bragg's law:**

$$2d\sin\theta = n\lambda$$

Where:

λ- is the wavelength,

d -is the distance between crystal planes,

θ -is the angle of the diffracted wave,

n- is an integer known as the order of the diffracted beam

$$2d\sin\Theta=n\lambda \quad \rightarrow \quad 2\sin\Theta=\lambda/d$$

$$2\sin\Theta/\lambda=1/d=S \quad \rightarrow \quad d=1/S$$

d - denotes the interplane distance, characteristics of the structure.

2.3 Small-angle scattering

Small-angle scattering of X-rays (SAXS) and neutrons is a fundamental method for structure analysis of materials. Usually SAXS is used to determine the structure of particle systems in terms of average particle sizes and shapes. SAXS probes structure in the nanometre to micrometer range by measuring scattering intensity at scattering angles 2θ close to 0°.In this angular range, information about the shape and size of macromolecules, pore sizes and the like is contained. SAXS is capable of delivering structural information about macromolecules. Small-angle X-ray scattering: is the research method of choice when the structures of multi -component systems (colloids) are investigated. Small angle X-ray scattering is used to investigate various kinds of polymers, emulsions**.**

2.4 Wide angle scattering

Wide angle X-ray scattering (WAXS) or Wide angle X-ray diffraction (WAXD) is a x-ray diffraction technique that is often used to determine the structure. This technique specifically refers to the analysis of Bragg peaks scattered to wide angles, which (by Bragg's law) implies that they are caused by sub-nanometer sized structures [$n*\lambda = 2d\sin\theta$]. Wide angle X-ray scattering is a technique concentrating on scattering angles 2θ close to 30°. Wide angle x-ray scattering is the same technique as Small-Angle X-ray Scattering (SAXS) only the distance from sample to the detector is shorter and thus diffraction maxima at larger angles are observed. A diffraction technique for polycrystalline films where only crystallites diffract which are parallel to the substrate surface.

The diffraction pattern generated allows determining the phase composition of the film, and the texture of the film. A solid consists of regularly spaced atoms (electrons) that can be described by imaginary planes. The distance between these planes is called the d-spacing. Every crystalline solid will have a unique pattern of d- spacing (known as the powder pattern), which is a “finger print” for that solid. In fact solids with the same chemical composition but different phases can be identified by their pattern of d-spacing.

We worked with these methods because: **x-ray scattering techniques** are a family of analytical techniques which reveal information about the structure and physical properties of materials and thin films. These techniques are based on observing the scattered intensity of an x-ray beam hitting a sample as a function of incident and scattered angle, and wavelength or energy.

3. UV-SPECTROSCOPY THEORY

3.1 Absorption spectroscopy

Spectroscopy is the study of the interaction between radiation (electromagnetic radiation, or light, as well as particle radiation) and matter. Spectroscopy studies the structure of matter and for qualitative and quantitative analyses. Recently, however, the definition has broadened as new techniques have been developed that utilise not only visible light, but many other forms of radiation. Spectroscopy is often used for the identification of substances through the spectrum absorbed by them. **Absorption spectroscopy** refers to a range of techniques employing the interaction of electromagnetic radiation with matter. In absorption spectroscopy, the intensity of a beam of light measured before and after interaction with a sample is compared. When combined with the word spectroscopy, the words transmission and reflection refer to the intensity of the beam measured after absorption and to that before. The description of the experimental arrangement usually assumes that there is a unique direction of light incident upon the sample, and that a plane perpendicular to this direction passes through the sample. Light that is scattered from the sample toward a detector on the same side of the sample is said to be detected in reflection and it is this light that is the subject of reflection spectroscopy. Absorption spectroscopy refers to techniques where one measures how much light of a particular wavelength (color) is absorbed by a sample. Since color can often be correlated with the presence or structure of a particular chemical, and since absorbance is often an easy and cheap measurement to make, absorbance spectroscopy is widely used for both qualitative (is a chemical present?) and quantitative (how much?) and structural (is it degraded?) work in a wide range of fields.

3.2 Equations

The method is using the Beer-Lambert law:

$$A=-\log_{10} (I/I_0) =\varepsilon\cdot c\cdot L$$

Where:

- A-is the measured absorbance
- I-is the transmitted intensity
- I_0-is the intensity of the incident light at a given wavelength

- c -is the concentration of absorbing species
- L-is the path length through the sample
- E- Is a constant known as the molar absorptivity or extinction coefficient

Experimental measurements are usually made in terms of transmittance (T), which is defined as:

$$\mathbf{T = I / I_o}$$

The relation between A and T are:

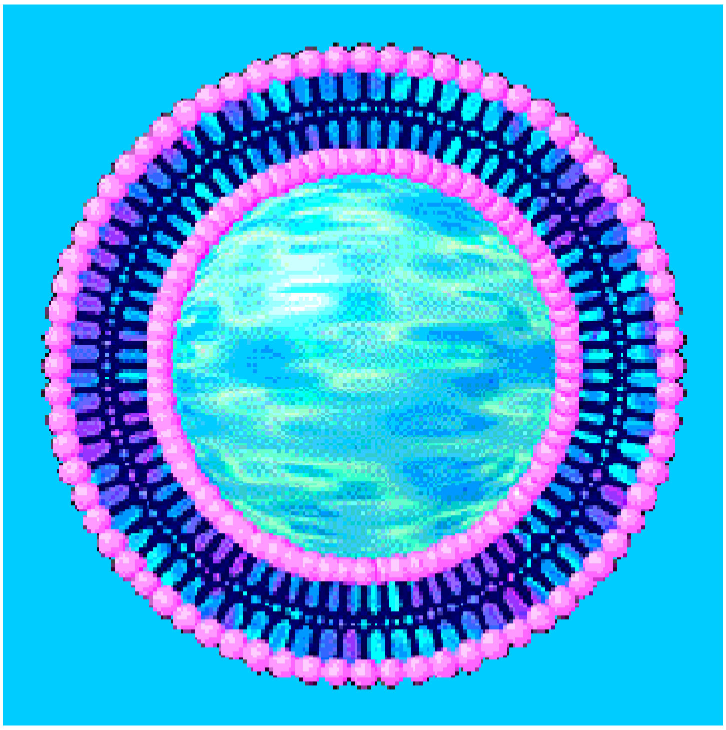
$$\mathbf{A = -\log T = -\log (I / I_o).}$$

Modern absorption instruments can usually display the data as transmittance, %-transmittance, or absorbance

4. EXPERIMENT

4.1 Structure of sunscreen

Sunscreen differs in the way of the organization of structure. Sunscreens are characterized by mesomorphism. A sunscreen is a multicomponent system. Such systems are formed by mixing molecules of the given substance and water. Molecules have on one end a polar group, on the other end a hydrophobic chain.. They form structures like the following: multilayer



Layers move relative to each other. These substance (absorption of ultraviolet radiation in organic molecules is restricted to certain functional groups (*chromophores*) that contain valence electrons of low excitation energy) absorb UV beams.

UV Spectrum:

Name	Abbreviation	Wavelength range in nanometres
Near	NUV	400 nm - 200 nm
UVA, long wave, or black light		400 nm - 320 nm
UVB or medium wave		320 nm - 280 nm
UVC, short wave, or germicidal		Below 280 nm
Far or vacuum	FUV, VUV	200 nm - 10 nm
Extreme or deep	EUV, XUV	31 nm - 1 nm

4.2 Composition of sunscreens

We have samples of commercial sun cream that one buys in a supermarket or pharmacy. We research following sunscreens: Russland 'Пляж' (SPF 30), Nivea Oil (SPF 2), Londa (SPF 8), England (SPF 5), Sun Expert (SPF 25), Daylong (SPF25), Matis (SPF10), Garnier (SPF 20), Glarins (SPF 20).

We study the structure. Sunscreens differ in composition. We investigated the following samples of sunscreens. The composition of samples:

Londa "SUN" Ingredients (SPF 8)

Aqua	IUPAC	Function
Ceteari1 isononanoate		
Ethylhexyl methoxycinnamate		UV – Filter
Octyldodecanol glyzerin		Solvent
C12-15 alkylbenzoate		Emollient
Butyl Methoxydiben zoylmethane		UV – Filter
Tocofheryl acetate		Antioxidant
Lauryl glucoside		
Polyglyceryl–2 dipolyhydroxystearate		Tensid
Carbomer		Emulsifying/gel forming
Acrylates/c10-C30 alkyl acrelate crosspolymer		

Benzoic acid		Desinfectant
Methylparaben		Preservative
Phenoxyethanol		Preservative
Propylparaben		Preservative
Dissodium EDTA		Chelating agent
Sodium hydroxide		Buffer
Parfum		

Nivea Oil Ingredients (SPF 2)

Paraffinum Liquidum C12-15 Alkyl Benzoate		Emollient
Caprylic/Capric Triglyceride		Emollient
Dicaprylyl Ether		
Dicaprylyl Carbonate		Solvent /emollient
Ethylhexyl Methoxycinnamate (EHMC)		UV - Filter
Tocofheryl acetate		Antioxidant
Butyl Methoxyben zoylmethane		UV - Filter
Simmondsia Chinensis		
Limonene		
Linolool		
Benzyl Benzoate		
Hydroxyisohexil-3-cyclohexene Carboxaldenyde		
Hexyl Cinnamal		
Benzyl Salicylate		UV - Filter
Eugenol		
Butylphenyl Methilpropional		UV - Filter
Alpha- Isomethyl lanone		

Citronellol		Disguising
Coumarin		Disguising
BHT Parfum		Preservative

England Ingredients (SPF 5)

Agua		
Ethylhexyl Methoxycinnamate (EHMC)		UV - Filter
Octhyldodecylneopentanoat		
Glycerin		Solvent
Ethylhexylsalicylat		UV - Filter
Eykozan crosspolymer		
Glyceryl stearate		Emollient
Cetyl Alcohol	Hexaddecan-1-ol	Emulsifying /emollient
Phentylene glycol		
Phenoxyethanol		Preservative
Cabomer		Emulsifying/Gel forming
Dissodium EDTA		Chelating agent
Methylparaben		Preservative
Propylparaben		Preservative
Tocofheryl acetate		Antioxidant
Trieethanolamin		Puffer
C30-38isopropyl maleat/crosspolymer		
Argynin		
Hydrogenated lecithin		
Extract cola bright		Plant
b-carotene		
Retinol palmitate		
Vegetable oil		
Parfum		

Russland 'Пляж'Ingredients (SPF 30)

Aqua		
Cetearyl isononanoat		
Octhyl stearate		Emollient
Sorbitol	D-Glicitol	Skin conditioning
Stearyl Epher		
Butylene glycol		
Panthenol		Antistatic / skin-maintaining
Octhyl Methoxycinnamate***		UV - Filter
Benzophenon – 3***		UV - Filter
1,2 Propylene glycol		
Tocofherol acetate		Antioxidant
Betayn AP		
Carbopol		
Dissodium EDTA		Chelating agent
NaOH		
Methylparaben		Preservative
Propylparaben		Preservative
Grindox-109		
Aloe Barbadensis		Emollient(Plant)
Parfum		

Daylong Ingredients (SPF20)

Aqua		
Ethylhexyl Methoxycinnamate (EHMC)		UV - Filter
Octocrylene	2- Propensaure-3-cyano-3,3- diphenyl-2 ethylhexylester	UV - Filter
Ethylhexylsalicylat		UV - Filter
Homosalate	Benzoic acid -2-hydrocsy- 3,3,5,-troimethylcyclohexylester	UV - Filter
Alcohol		
Dicaprylyl Maleate	Dioctylmaleat	Emollient
Sorbitol	D-Glucitol	Plasticizer/skin conditioning
Bis-Ethylhexyloxyphenol Methoxyphenyl		UV - Filter

Triazine (BEMT)		
Triethanolamin		Puffer
Lecithine		
Aloe Barbadensis		Emollient(Plant)
Dimethicone		Intifoam
Methylparaben		Preservative
Carbomer		Emulsifying/Gel forming
Cetyl Alcohol	Hexaddecan-1-ol	Emollient
Tocofherol acetate		Antioxidant
Citric acid		Puffer
Potassium sorbate, BHT		Preservative
Sodium Benzoate		Preservative

Garnier Ambre Solaire (Sonnemilch) SPF 30,Ingredients

Aqua		
Octocrylene	2- Propensaure-3-cyano-3,3-diphenyl-2 ethylhexylester	UV - Filter
Glycerin		Solvent
Cyclopentasiloxane		
Isohexadecane		
C12-15 Alkyl Benzoate		Emollient
Titanium dioxide		UV - Filter
Butyl Methoxydibenzoylmethane		UV - Filter
Potassium cetyl phosphate		Tensid
VPI eicosene copolymer		
Stearic acid		Emollient
PEG -100 stearate		Tensid
Ethylparaben		Preservative
Triethanolamin		Puffer
Dimethicone		Intifoam
Limonene		

Xanthan gum		Verdicker
Linalool		
Benzyl Salicylate		UV-Filter
Propylparaben		Preservative
Isoputylparaben		Preservative
Alpha isomethil ionene		
Terephthlidene dicamphor sulfonic acid		UV - Filter
C10-30 alkyl acrylate crosspolymer		
Sorbitol		Humid holds means
Dissodium EDTA		Chelating agent
Methylparaben		Preservative
Butylparaben		Preservative
Butylphenylmethylpropional		
Citronellol		Disguising
Citral		Disguising
Aluminium hydroxide		Smoothly doing
Opuneia coccinellifera		Plant
coumarin		Disguising
Glyceryl stearate		Emollient
Glycine soja		Plant
Parfum		

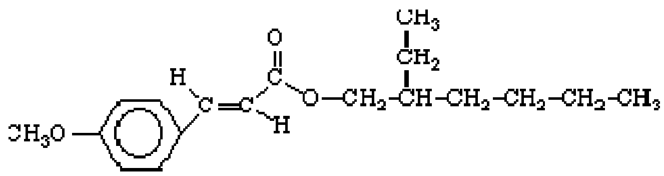
Sun Expert Ingredients (SPF 25)

Aqua		
Ethylhexyl Methoxycinnamate (EHMC)		UV - Filter
Dicapryl Carbonate	Dioctylcarbonat	Solvent/emollient
Glycerin		Solvent
Ethylhexylsalicylat		UV - Filter
Homosalate	Benzoic acid-2-hydroxy-3,3,5 troimethylcyclo-hexylester	UV - Filter
Benzophenon – 3***		
Dimethicone		Antifoam Emollient
Potassium cetyl phospate	Kalium-1-hexadecanolphosphat	Tensid
Cetyl Alcohol	Hexaddecan-1-ol	Emuslifying/gel forming

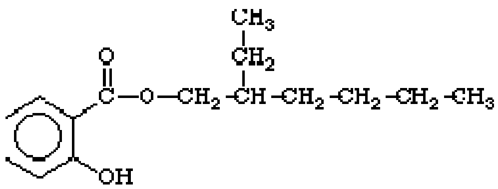
Trieethanolamin		Puffer
Methylparaben		Preservative
Propylparaben		Preservative
Propylene glycol		
Cetearyl sulphat Na		
Tocofherol acetate		Antioxidant
Carbomer		Emulsifying /gel forming
EDTA		Chelating agent
Parfum		
Phenylbenziimidazole sulfonic acid		

Active ingredients are a term familiar to everyone. The structures for the active ingredients in sunscreens are shown in Figure 2. What properties do these compounds have that make them active ingredients? They are chromophores.

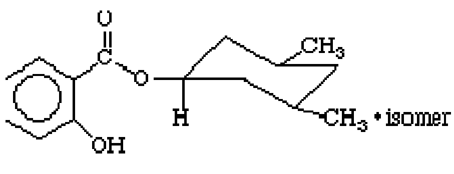
Figure2: Structures of the active ingredients in sunscreens



2-ethylhexyl-p methoxycinnamate



2-ethylhexylsalicylate



homosalate

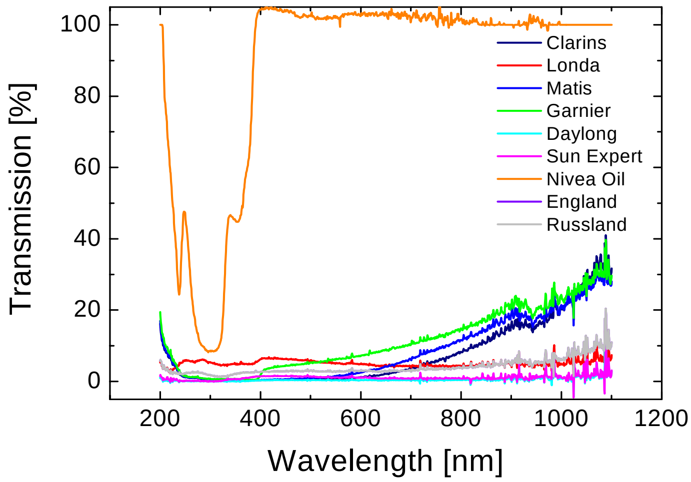
Sunscreens are made up of chemicals that can absorb specific wavelengths of the sun's spectrum: 2-ethylhexyl 2-cyano-3, 3- diphenylacrylate - Also known and of the cinnamate group of chemicals, this compound absorbs light with wavelengths from 250nm to 360nm.

4.3Experiment with UV-spectroscopy

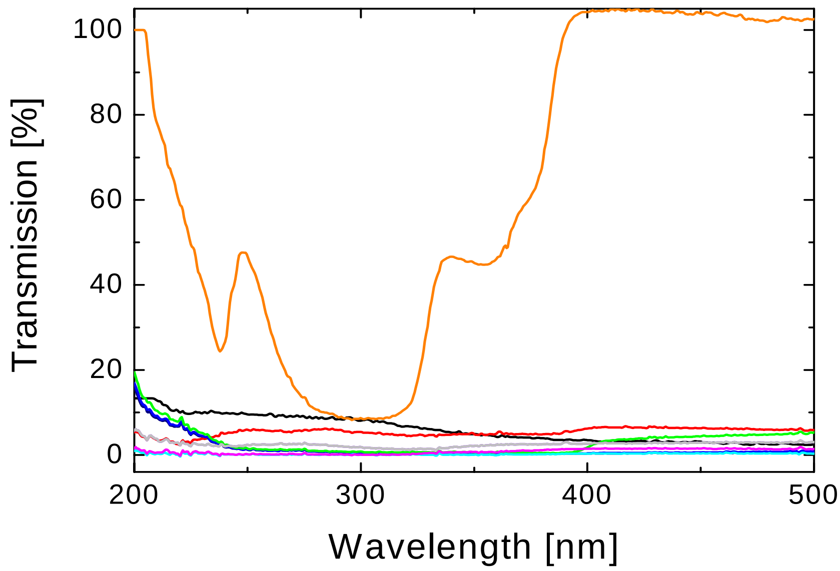
Sunscreen samples were studied on "TRISTAN" MANUAL spectrometer.

Experiment 1

Measurements of uv-absorption were done at normal conditions (25 ^{0}C). We obtain these results: Daylong, Sun Expert, have transmission coefficient lower than 0 % for whole range uv-light., Garnier, Glarins, Matis have transmission coefficient lower than 1 % for whole range uv-light. Russland have transmission coefficient lower than 4 %, Londa have transmission coefficient lower than 5 %.

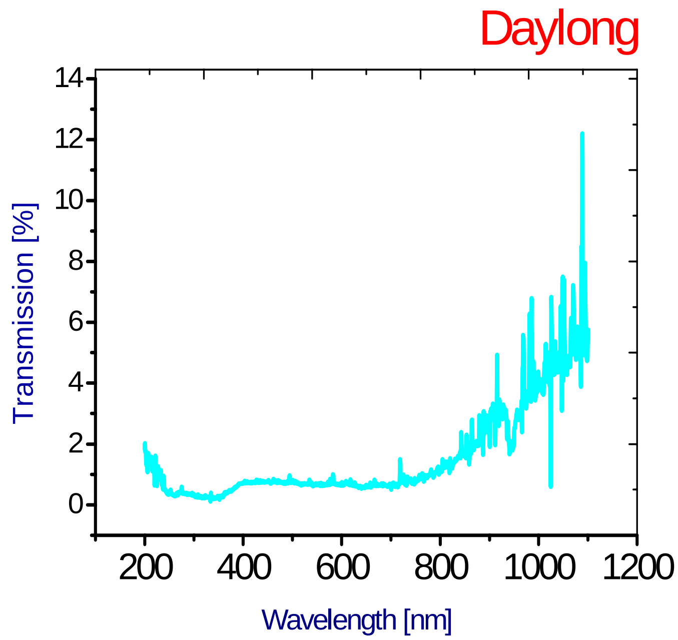


Picture 1: Spectra of absorption of samples



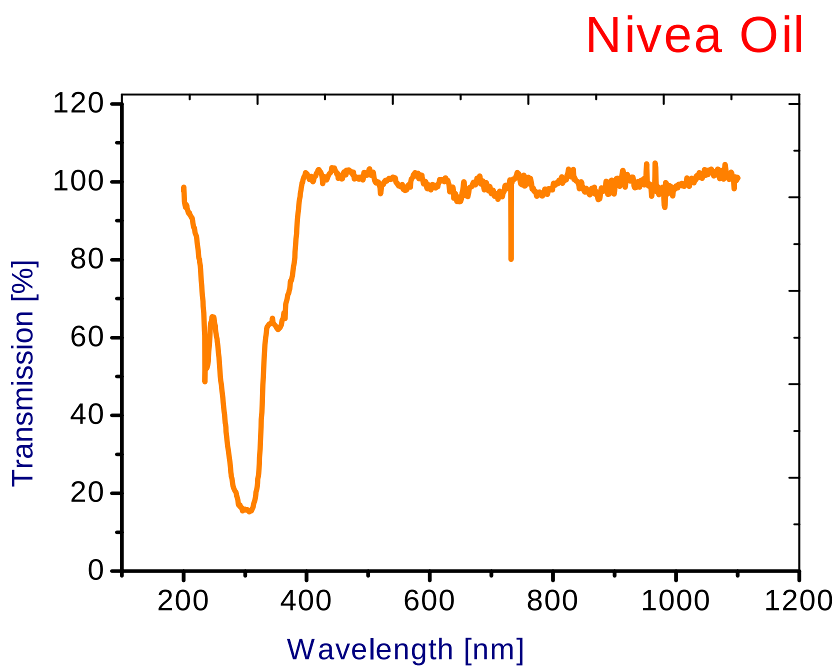
Picture 2: Transmission [%] in UVA (320-400 nm) and UVB (320-280 nm) spectrum

Sample Daylong SPF 20 absorb uv-light better than other sunscreens in whole uv-spectrum. It has the best defense against uv-light.



Picture 3: Spectra of absorption of Daylong, (SPF 20)

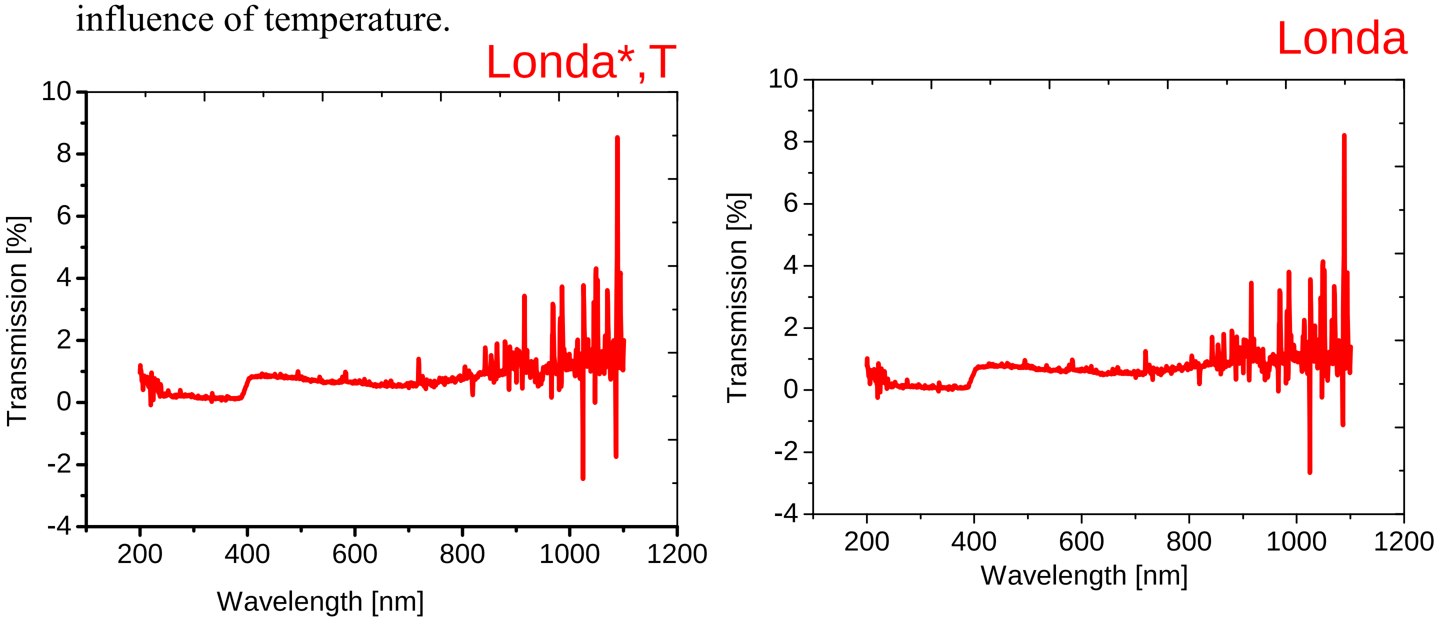
Sample Nivea Oil (SPF 2) has the lowest coefficient of absorption. T,% = 100 %.It has no defence against uv-light.



Picture 4: Spectra of absorption of Nivea Oil, (SPF 2)

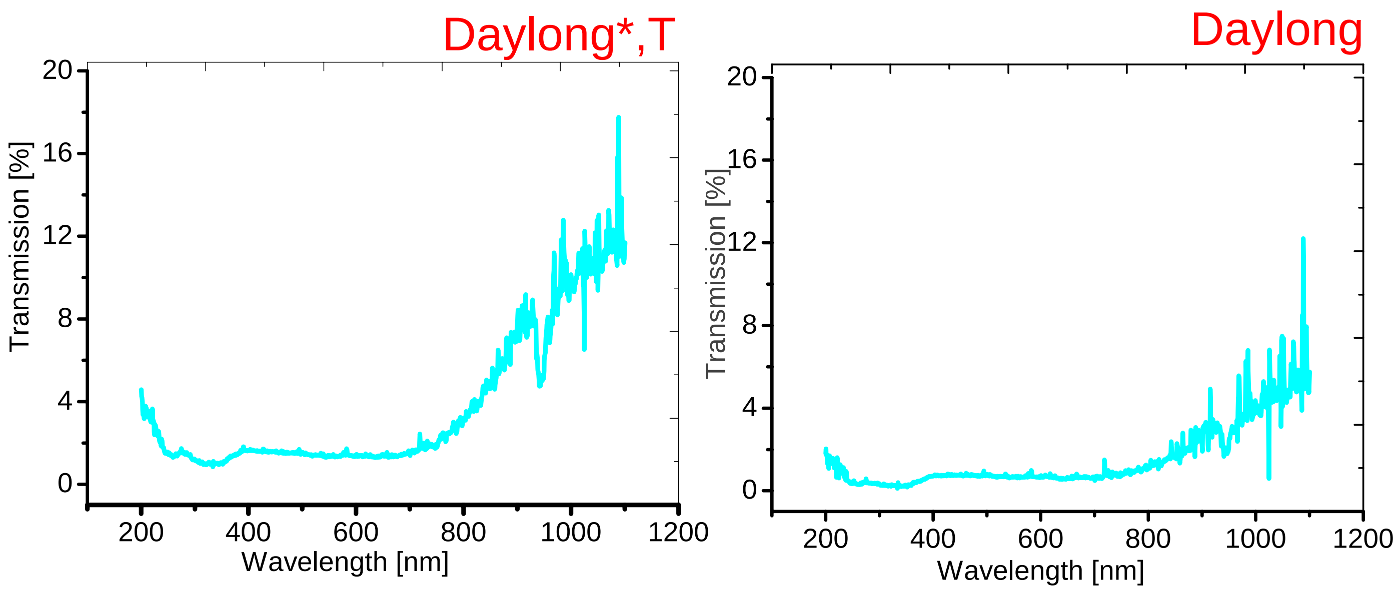
Experiment 2

Samples of sunscreen were heated before measurements. It was done to check whether they will change their ability to absorb uv-light. Temperature ranges were 25 ^{0}C- 65 ^{0}C- 25 ^{0}C. Samples of sunscreens (Londa, Garnier, Glarins, and Sun Expert) have not changed value of factor transmission after influence of temperature.



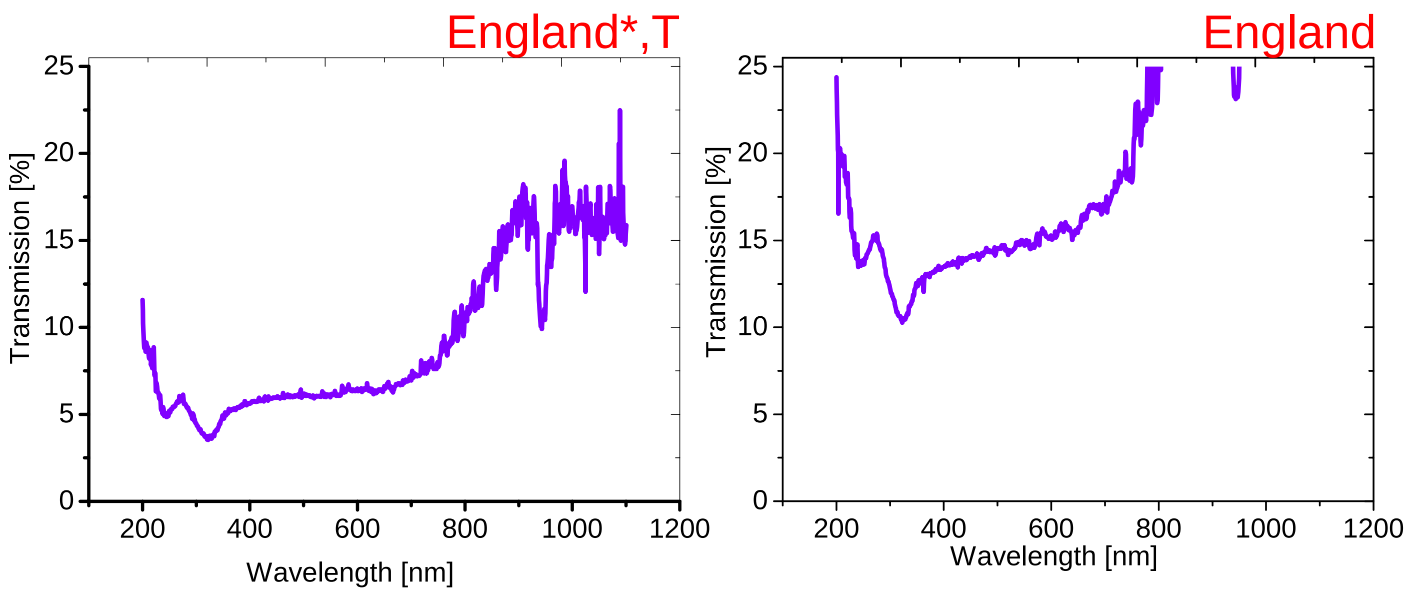
Picture 5: Spectra of absorption of Londa, (SPF 8)

Samples of sunscreens (Russland, Daylong) began to absorb UV-light (has increased factor transmission) after influence of temperature.



Picture 6: Spectra of absorption of Daylong, (SPF 20)

The factor transmission has decreased after influence of temperature at sunscreens: England, Matis.



Picture 7: Spectra of absorption of England, (SPF 5)

Sunscreens didn't change their absorption properties after heating.

4.4. Experiment with X-ray diffraction

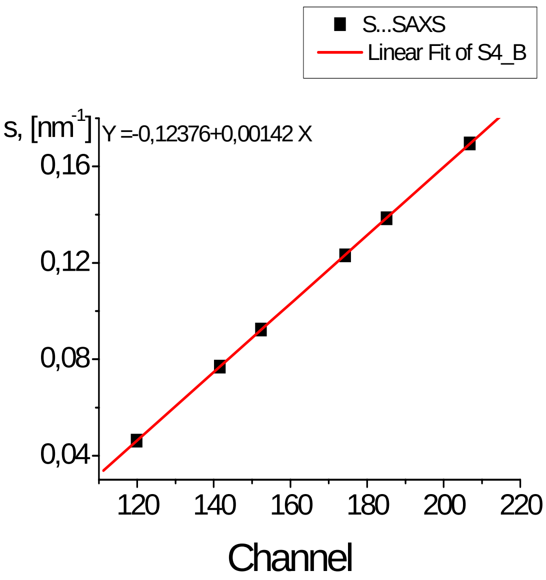
Beemline A2 of HASYLAB

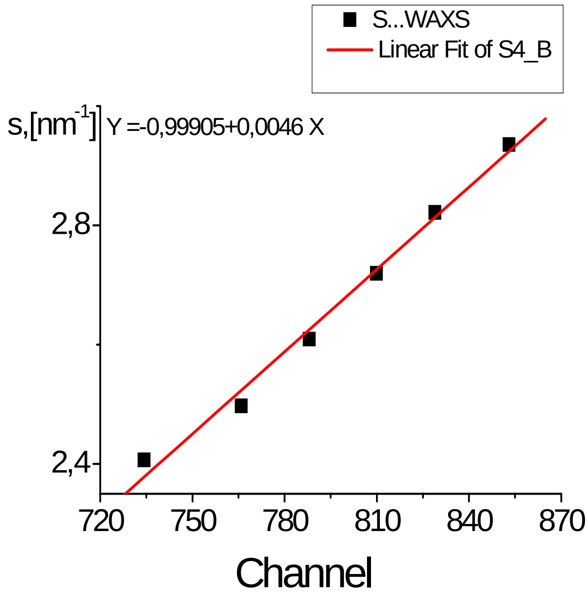
The thermostability – the characteristic of quality of a sunscreen. Components of a sunscreen change the macrostructure, if they are not thermostable. To study the macrostructure of a sun protection cream is important.

4.4.1 Calibration.

Calibration for detector was done using RTT and Tripalmitin

RTT (rattail)–saxs calibration **Tripalmitin – waxs calibration**





Picture 8: saxs and waxs calibration

Corresponds to the equation:

Y= a + b*x → S= a + b*channel → d=1/S

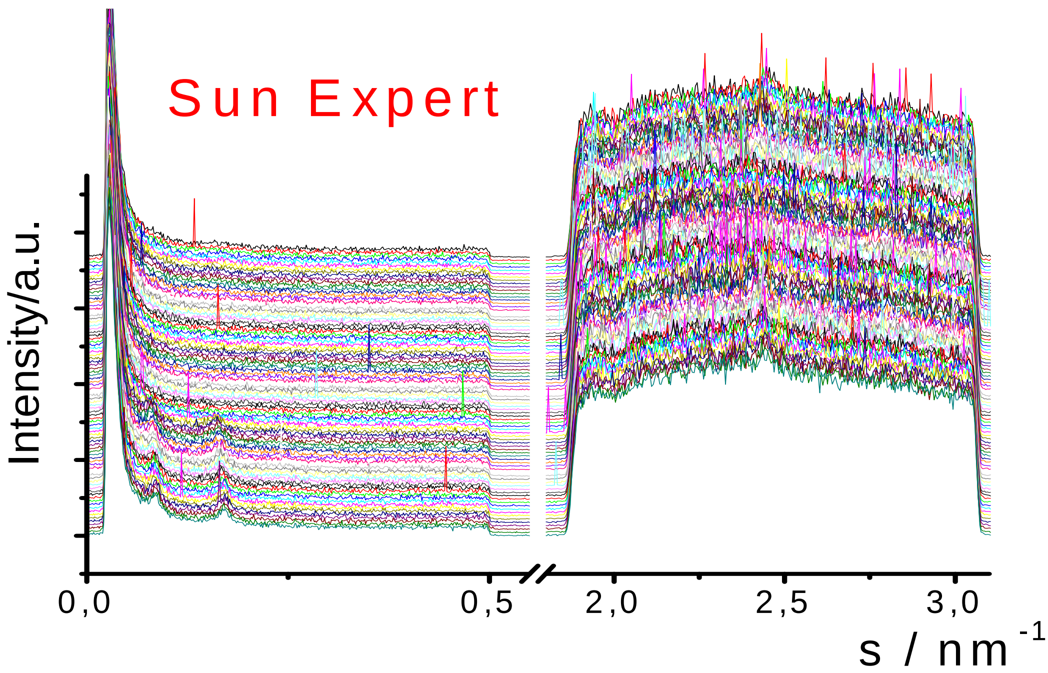
From this equation we find the parameter d, the interplane distance. From these data it is possible to get the information on the macrostructure of a substance.

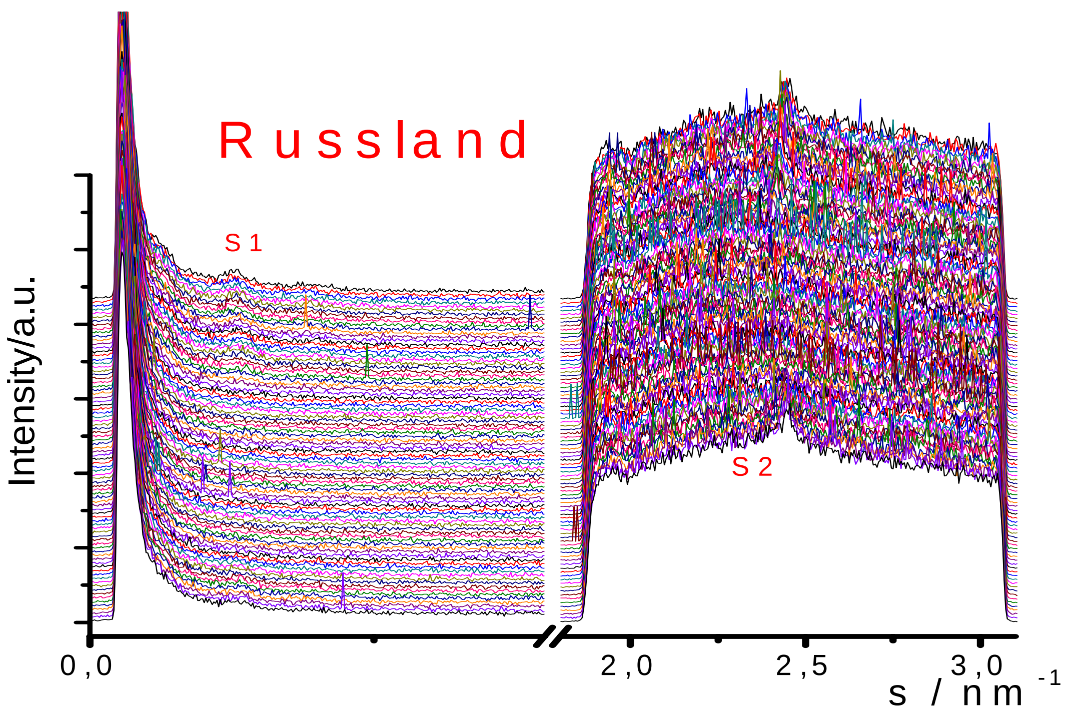
4.4.2 Temperature regime

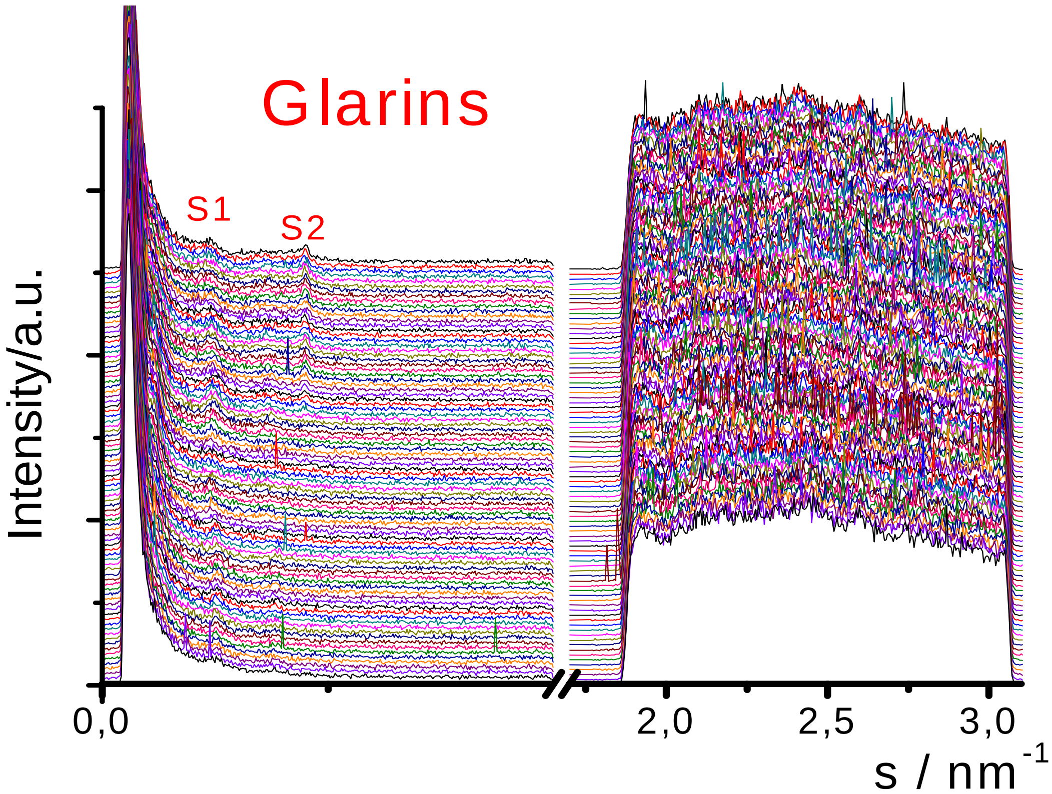
We are going to see the structural and thermal behaviour of sunscreens, using small angle x-rays scattering/diffraction.

What happens with their macrostructure, if there is any, upon heating? Does one see changes, or not?

We studied behaviors of sunscreen in an interval of temperatures 25^0-65^0-25^0 ^{0}C, (1 ^{0}C/min). These sunscreens changed their macrostructure: Sun Expert (SPF 25), Glarins (SPF 20), and Russland 'Пляж' (SPF 30). These sunscreens have regular structure. We calculated parameter d for this creams.


Sun Expert
Intensity/a.u.
0,0
0,5
2,0
2,5
3,0
s / nm -1


Russland
S 1
S 2
Intensity/a.u.
0,0
2,0
2,5
3,0
s / nm -1



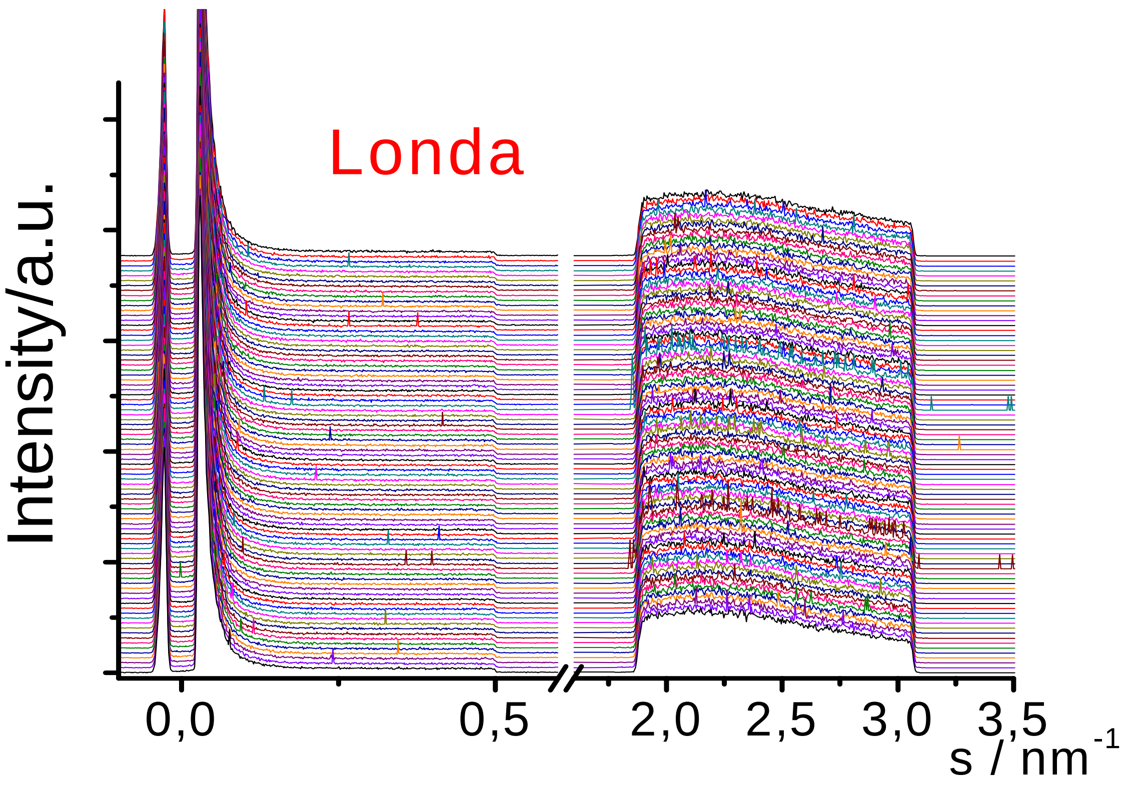
Picture 9: Structure of sunscreens

Tab 1: Interplane distance for sunscreens

Name of the sunscreen	s, nm^{-1}	D, nm - interplane distance
Sun Expert (SPF 25)	s_1=0.086 s_2=2.44	D_1=11.63 d_2=0.41
Russia ‘Пляж’ (SPF 30)	s_1=0.412 s_2=2.437	D_1=2.429 d_2=0.41
Glarins (SPF 20)	s_1=0.119 s_2=0.226	D_1=8.399 d_2=4.43

They are not thermostable. These are of interest for the further research. It is necessary to answer a question. At irradiation by UV light the substance does not collapse. We can obtain the data on structure. We use UV spectroscopy. After that, we measure the UV absorption and look for correlation between structure and UV absorption.

Sunscreens Londa, Matis, Nivea Oil, Daylong, Garnier, England don’t have regular structure. We can’t define parameter d (interplane distance).



Picture 10: Structure of sunscreens

Conclusion

1. Using x-ray scattering macrostructures of creams have been investigated. For sunscreens Expert (SPF 25), Glarins (SPF 20), and Russland 'Пляж' (SPF 30).we determined the values of parameter d.

2. At carrying out of research on the device we have found out that the temperature influences structure of a sunscreen. Under action of heating there is a change of the macrostructure. The macrostructure of sunscreens Expert (SPF 25), Glarins (SPF 20), and Russland 'Пляж' (SPF 30) has changed.

3. Using the data on UV-spectroscopy we have studied spectra of absorption of sunscreens. Research of creams on a spectrometer has shown that the temperature does not influence ability to absorb UV-light. Change of a macrostructure under action of temperature does not influence efficiency of absorption of UV-light.