Titel: Oriënterend onderzoek naar de mechanismen van `Anfeuerung`

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Inhoudsopgave

Inleiding

Anfeuerung is een subjectief begrip waarmee de uitstraling van een blank laksysteem beschreven wordt. Eigenschappen als de helderheid, dieptewerking, aankleuring en vloeigedrag spelen hierbij een rol. Bij donkere houtsoorten (zoals mahonie, kersen of teak) waarbij een warme uitstraling vereist wordt, kan de toepassing van watergedragen blanke lak ten koste gaan van de warme uitstraling. Vooral op grofporige houtsoorten (zoals eiken, essen) speelt ook het vloeigedrag een belangrijke rol. Dit onderzoek heeft tot doel inzicht te verkrijgen in die parameters die de Anfeuerung beïnvloeden zodat de Anfeuerung van watergedragen lakken verbeterd kan worden. Ook bij blanke lakken kunnen dan meer oplosmiddelhoudende door watergedragen producten vervangen worden.

Als eerste stap in het project voerde SHR een literatuurstudie uit naar het mechanisme van “Anfeuerung”. Hierop wordt in een tweede deel voortgeborduurd met laboratoriumonderzoek waarin de eigenschappen, die voor “Anfeuerung” zorgen, worden vastgesteld.

De resultaten van het onderzoek zijn verwerkt in een wetenschappelijke publicatie en een presentatie die gehouden is op het internationale Wood Coating Congres van 16-19 oktober 2006. De volledige publicatie is als bijlage opgenomen in dit rapport. Hieronder volgt een korte Nederlandse samenvatting van het onderzoek.

Samenvatting

Uit het uitgebreide **literatuuronderzoek**, blijkt dat zeer weinig bekend (en gepubliceerd) is over de mechanismen van Anfeuerung. Een aantal artikelen handelen uitgebreid over de toepassing van (nieuwe) blanke afwerksystemen waarbij het fenomeen “Anfeuerung” of “wet look” wel wordt genoemd, maar niet verklaard.

Medio augustus 2006 is van één van de betrokken bindmiddelfabrikanten aanvullend informatie ontvangen over een onderzoek dat ze hadden uitgevoerd naar één van hun watergedragen producten met verbeterde Anfeuerung effect. Het onderzoek was uitgevoerd op eiken en beuken. Behalve vrij gangbare beproevingen die eigenschappen van een meubeloppervlak bepalen, zijn ook een aantal testen uitgevoerd waar meer informatie over Anfeuerungseffecten uit gehaald konden worden.

Gebaseerd op bovenstaande dragen waarschijnlijk de volgende factoren bij aan een beleving van het Anfeuerungseffect:

- ***Helderheid.*** Heldere lakken kunnen zorgen voor een hogere Anfeuerung. Deze wordt door een aantal parameters bepaald die productspecifiek kunnen zijn of een gevolg zijn van de applicatie(voorbereiding). Een voorbeeld van dat laatste is *luchtinslag*. Blanke of transparante lakken waar veel (kleine) luchtbellen ingesloten zijn hebben een lagere helderheid. De

luchtbellen zorgen namelijk voor brekingsindexverschillen waardoor het (invallend en uitredend) licht wordt verstrooid.

Inhomogeniteit van de lak zelf (van het mengsel) is een productspecifieke eigenschap die zorgt voor verstrooiing van licht en een verminderde helderheid. Een andere betreft de eigenschappen van het bindmiddel dat als basis dient voor de (blanke) lak. Als dat een anisotroop polymeer is zijn moeilijkere omstandigheden nodig om *kristallijne structuren* te vormen. Kristallijne structuren zorgen voor een verstrooiing van licht en verminderde helderheid (matter, troebeler). Anisoptrope polymeren resulteren juist in amorfe structuren die helderder zijn. Mogelijk is hiermee een Anfeuerungseffect te sturen van alternatieve lakken. Producten die bij lagere (kamer)temperaturen een kristallijne structuur hebben, kunnen door uitharding bij hogere temperaturen juist anisotroper vernetten en dus helderder zijn.

Een derde eigenschap van de lak zelf die voor een lagere helderheid zorgt is de *onverdraagzaamheid van verschillende componenten*. Sommige additieven (verdikkers, ontschuimers, pigmenten) mengen minder goed met de polymeren van een bindmiddel en zorgen daardoor voor verstrooiing van het licht. Bovengenoemde karakteristieken zorgen in principe wel voor een lak die voldoende lichtdoorlatend is, maar niet helder genoeg (door verstrooiing van het invallend en uittredend licht). De lak zelf kan ook een lage doorlatendheid hebben die zorgt voor een lage helderheid. Dit wordt dan veroorzaakt door *lichtabsorberende elementen* in de lak.

- ***Kleur.*** Uit onderzoek blijkt dat een rodere kleur gerelateerd wordt aan een warmere visuele beleving. De kleur van een houtsoort wordt bepaald door inhoudstoffen, die veranderen onder invloed van pH (zuurgraad). Vrijwel alle houtsoorten zijn zuur (lage pH), terwijl watergedragen lakken veelal alkalisch (hoge pH) zijn. Hierdoor verandert de samenstelling van de inhoudstoffen en derhalve de kleur. Het hout wordt groener en lijkt minder “nat”. Dit effect is vooral groot bij houtsoorten die van nature zeer zuur zijn, zoals eiken en essen. Twee houtsoorten, overigens die van nature juist een groene schijn hebben! Verder mobiliseert de hogere pH de houtinhoudstoffen, waardoor die in de laklaag kunnen migreren en voor vlekken kunnen zorgen.

Om verder uitsluitsel hierover te krijgen zijn een aantal **laboratoriumproeven** uitgevoerd.

Een aantal onderzoekers, vertegenwoordigers van meubelfabrikanten en lakleveranciers en consumenten hebben beuken, kersen en eiken panelen beoordeeld. Deze waren afgewerkt met 5 verschillende blanke afwerksystemen (oplosmiddelhoudend en watergedragen). de beoordelaars moesten aangeven welke afwerking het grootste Anfeuerungseffect had. Deze volgorde is vergeleken met kleurmetingen. Hieruit bleek dat de visuele evaluatie door de panelleden meer overeenkwam met de indruk van de kleur dan met contrast. Deze overeenkomst was groter bij de beoordeling van de

onderzoekers dan bij de overige panelleden. Op kersen werd door de consumenten in de panels een watergedragen systeem geprefereerd boven de nitrocelluloselak.

Bij aanvullende testen werd gevarieerd in pH (zuurgraad) en NCO/OH-verhouding. reproduceerbaarheid van de beproevingen vormde hierbij een probleem. De kleur van het benatte hout veranderde zo snel (donkerder) dat hiermee de herhalingen beïnvloed werden.

Variaties in formulering (m.n. isocyanaat) hadden, volgens deze evaluaties, nauwelijks effect op de Anfeuerung. Mochten er wel kleine verschillen aanwezig zijn, dan zijn andere meetmethoden nodig om die aan te tonen. Vooralsnog lijken de kleurmetingen een redelijk onderscheid te kunnen maken in Anfeuerungseffect van een type lak. Uitgebreide beproevingen aan meer panelen en typen afwerking moeten dit verder onderbouwen. Hierbij is het wel van belang dat de verschillende marktpartijen (lakleveranciers, meubelfabrikanten en consumenten) eenduidig overeenkomen wat zij onder Anfeuerung verstaan.

Bijlage 1 Publicatie over onderzoek naar Anfeuerung zoals gepresenteerd op het Wood Coating Congress, 16-19 oktober 2006 in Praag

Factors Influencing Wet Look of Clear Coatings on Wood ("Anfeuerung")

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Abstract

At present, subjective methods are used to classify the degree of "Anfeuerung" of a coated surface. This study is about finding measurable parameters influencing this phenomena in order to be able to develop a method to objectivate the classification of "Anfeuerung".
Therefore a literature search was performed, to learn about the phenomena and to find directions for further steps. Based on these results, a definition for "Anfeuerung" is suggested that enables a practical set up for primary testing. Furthermore a simple method for classifying "Anfeuerung" by colour measurements was proposed and evaluated.

1. Scope of work

"Anfeuerung" is a term that characterises the appearance of a clear lacquer on wood. It contains properties such as enhancement of the wood structure, lightness, colouring, wetting, gloss and levelling. These properties are important for the general appearance, "the looks", of coated wooden surfaces. Terms which are also used to describe this effect are "wet look" or "low haze".
Usually it is not a problem to get good "Anfeuerung" when using solvent based coatings. But when using waterborne lacquers, which share is increasing due to environmental or health reasons, these properties are often absent or appear in lower "amounts". Especially for dark wood species, where a warm glow is required, this effect can be seen as a very weak one.

Today "Anfeuerung" is very subjectively used in literature. There is no uniformity in definitions and the term is used whenever convenient in the text to approve or disapprove of a lacquer or coated surface in respect to market standards.

The ultimate goal of this research is to gain information about "Anfeuerung", understand parameters that influence this effect, find ways to describe this phenomena and to develop an objective measuring method for the classification of Anfeuerung. Final goal is to be able to improve the "Anfeuerung" of water borne coating systems in the future. In order to do so, a scale for evaluating and measuring "Anfeuerung" is required.

The first step in this consists of the development of a simple test method to measure diferent panels objectively.
The scope of this research was to objectivate the term Anfeuerung to be able to measure Anfeuerung so different coating materials (coated surfaces) can be compared and it will become possible to point out good, less VOC containing, alternatives for the solvent borne lacquers used in the furniture industry today.
If “Anfeuerung” can be measured it will, at the same time, become more easy to study the influence of coating composition and formulation parameters on Anfeuerung.

2. Materials and Methods.

2.1 Literature study

A literature study was performed on the state of the art of “Anfeuerung”. Search terms such as Anfeuerung, lasur, möbellack, wet look, woodcoating, waterborne / based, furniture, appearance, luster and wood grain were used, among other related terms.
For this purpose three libraries were visited to get access to various databases.

- Wageninge University (WUR) library Haaf – SciFinder Scholar, ELFIS (German), SCOPUS (SCIRUS-web)
- AKZO NOBEL library – WSCA (abstracts: Jan., Feb., Mar. 2006) + WSCA web database
- Delft University (TUD) library – Compendex, WSCA (World Surface Coatings Abstracts), Web of Knowledge, Web of Science, ELFIS;

2.2 Experiments

2.2.1 Evaluation of visual assessment and colour measurement

Two commercial volatile organic compounds (VOC) containing products with good Anfeuerung properties were received and binder manufacturors were asked for their latest developments in waterborne products for coatings with good Anfeuerung. Also, four water borne products were selected in order to cover a broad range of ratings for Anfeuerung.
Five (out of these six) commercial coating materials were applied to three wood species: beech, oak and cherry:

1. VOC 2K PU
2. VOC Nitrocellulose lacquer
3. Acrylic waterborne
4. Waterborne 2K PU
5. Waterborne acrylic

It was tried to exclude all coating defects that might cause disturbance of the Anfeuerung

Coated samples were prepared and inspected, visually and by colour measurement.
Visual assessments were performed by a panel of three researchers, a panel of furniture manufacturors, coating manufacturors and customers (end users of furniture). Each evaluator was

asked to give his or her opinion about contrast,colour and overall (Anfeuerung) impression. Panels with all coating systems had to be ranked in order of having the best contrast / colour / overall.

Colour measurements were performed according to a simple test method, which was developed based on the information that resulted from the literature scan. Therefore a number of possibly measurable parameters was evaluated resulting in the following method:
A Minolta Spectrofotometer C2600 was used. Both coated and freshly wetted wood were measured (Specular Component Excluded) and a Delta E value was calculated. Each measurement consisted of a mean value of five measurements at the same spot. Specular Component Excluded (SCE) measurements mean that de specular reflectance, like a mirror, is excluded from measurement and only the diffuse reflectance is measured.

2.2.2 Change of pH

For a water borne acidic binder with good “Anfeuerung” expectations a standard coating formulation was prepared as follows (Table 1):

Table 1. Standard coating formulation.

Binder /additive	Amount added [wt-%]
binder	85,4
defoamer	0,5
cosolvent 1	2,6
cosolvent 2	2,6
thickener	0,8
defoamer	0,1
water	8,0
Total amount	100,0

This formulation had a standard pH value of 6. The pH value was lowered to 4.5 using acetic acid and also increased to 7.5 and 9 by adding ammonia. In order to prevent coagulation of the binder, this was done slowly and with constant stirring.
These four mixtures were applied in two layers with a doctor blade to beech, oak and cherry panels. In order to exclude influences from the substrate as much as possible, all formulations were applied to one panel for each wood species.

2.2.3 Change of NCO/OH ratio

For a waterbased binder a standard coating formulation was prepared (Table 1). For this isocyanate crosslinkable binder the NCO/OH ratio was varied. The isocyanate used was diluted in 17 wt-% of solvent (K2). The NCO/OH ratio was varied as follows (Table 2):

Table 2. Variation of NCO/OH ratio by adding a second component (K2) to the standard formulation and the effect on the total amount of cosolvent in the formulation.

NCO/OH ratio	K2 [g] added per 100g basis	Cosolvent [wt-%]
0	0.0	5.2
0.4	12.0	6.4
0.8	24.1	7.3
1.2	36.1	8.1

The amount of cosolvent increases with increasing NCO/OH ratio. The increasing viscosity with increasing NCO/OH ratio was compensated by adding a little amount of water to the mixture before coating application.

These four mixtures of increasing NCO/OH ratio were applied with a doctor blade to beech, oak and cherry panels. In order to exclude influences from the substrate as much as possible all formulations were applied to one panel for each wood species

3. Results

3.1 Literature Study

The publications that were found with the closest match to our search terms are shown in Appendix A. Only two publications were found with a useful contribution about the meaning of Anfeuerung and factors of influence in Anfeuerung behaviour of waterborne coatings:

Riemann [1] has a definition of Anfeuerung in 1993 that represents the Rohm & Haas approach of that time: Anfeuerung is the phenomena that the naturel colours of wood become more intense after application of a lacquer.

According to Riemann the following parameters should be of influence on Anfeuerung:

- wetting of the wood pores: Even the smallest occurence of enclosed air in individual pores gives a relative haze in the coating. Water borne coatings suffer more from this problem than solvent based coatings. Morphology and chemical composition of the water borne polymers used, have a great influence on this.
- Swelling of the wood: Due to contact with water a negative influence is seen. Drying should be as quickly as possible. This is also useful for minimising mobility of wood extractives.
- Rheological behaviour of the lacquer, the more Newtonian the better.

Berkhout [2] presented in 2004 the vision of Johnson Polymer (today BASF) on “Anfeuerung”. Their description was in statements rather than as a definition, Anfeuerung is

- a German expression, but widely accepted in the coatings market to describe the optical performance [of a transparent coating, NLS] on wood.
- Highlighting the grain structure of the wood
- Accentuation of the wood grain
- The wet look
- Depth of image (3D-effect)
- The warmth of the wood
- A reddish appearance on tannin-rich wood species
- The enhancement of the natural beauty of high quality wood species

- And… one of the last hurdles to take in order to have a succesful conversion to waterborne coatings in the furniture market!

Both Riemann and Berkhout point out that binder composition determines what level of Anfeuerung can be reached.

This last remark touches the scope of our project. The Dutch Association of Furniture Producers (CBM) asked SHR to help develop their members knowledge on this subject in order to accelerate development and acceptation of waterborne coatings.

Putting together the results of the literature search and thinking over the meaning and influence of all parameters mentioned before, the idea rose that all parameters involved in coating application should not be taken into account in our evaluation. Naturally a coating has to be applied without air inclusions, without film defects, or whatever defect that might disturb the clarity of the coating in order to obtain the best possible Anfeueung. Coating formulation is used to improve all these parameters. In our experiments we took great care in applying defect free films to the wooden panels.
What really matters is the colour of the coated wood and the contrast that can be observed comparable to wood wetted with water.

Therefore colour measurement on coated and wetted wood seems to be the most practical approach to discriminate coatings with good Anfeuerung from coatings with less Anfeuerung.

3.2 Visual assessment and colour measurement

3.2.1 Visual assessment and colour measurement (researchers panel)

The tables 3, 4 and 5 show the results for the three woodspecies as resulting from the visual assessment by three researchers.

Table 3. Beech panels, evaluation for contrast, colour and overall impression by a panel of researchers, and colour measurement (Delta E).

Beech	best				>>>				worst
Contrast	3	>	2	>	1	>	4	>	5
Colour	2	>	1	>>	4	>	5	>>	3
Overall imp.	2	>	1	>>	4	>	5	>>	3
Delta E	2 (2.7)		1 (5.7)		5 (7.6)		4 (9.5)		3 (10)

Table 4. Oak panels, evaluation for contrast, colour and overall impression by a panel of researchers, and colour measurement (Delta E).

Oak	best				>>>				worst
Contrast	2	>	4	>	1	>	5	>	3
Colour	2	>	1	>	4	>	5	>	3
Overall imp.	2	>	1	>	4	>	5	>	3
Delta E	2 (1.7)		1 (2.2)		4 (4.3)		5 (4.5)		3 (6.3)

Table 5. Cherry panels, evaluation for contrast, colour and overall impression by a panel of researchers, and colour measurement (Delta E).

Cherry	best				>>>				worst
Contrast	2	>	1	>	4	>	3	>	5
Colour	2	>	1	>>	4	>>	5	>	3
Overall imp.	2	>	1	>>	4	>>	5	>	3
Delta E	2 (1.8)		1 (3.2)		4 (5.9)		3 (7.1)		5 (9.5)

Visual assessment of contrast clearly gives different results compared to visual assessment of colour. The overall impression is apparently more influenced by colour than by contrast.
Colour measurement shows, in most cases, the same order than obtained from the visual assessment for colour and overall impression by the researchers panel.

The researchers furthermore noticed that on beech, lacquer 3 levels out the natural colour differences in the wood and lacquer 2 accentuates them.
On oak, lacquer 2 accentuates the rays in the wood and also the natural colour differences and lacquer 3 levels them out on oak.

On cherry lacquer 3 is very clear but it gives a uniform colour impression and it levels out the natural colour differences of the wood.

3.2.2. Visual assessment and colour measurement (manufacturors and customers panel)

The tables 6, 7 and 8 show the results of the visual assessment by the panel of furniture and paiint manufacturors and customers. Appendix B shows all individual data and a comparison of the results from the panel of furniture and paint manufacturors and customers to the results of the researchers panel and the colour measurements.

Table 6. Beech panels, evaluation for overall impression, contrast and clarity by a panel of furniture and paint manufacturors and customers, and colour measurement (Delta E).

Beech	best				>>>				worst
Overall	2	>	4	/	5	/	3	>	1
Contrast	2	>	3	/	4	/	5	>	1
Clarity	2	>	4	/	5	/	3	>	1
Delta E	2 (2.7)		1 (5.7)		5 (7.6)		4 (9.5)		3 (10)

Table 7. Oak panels, evaluation for overall impression, contrast and clarity by a panel of furniture and paint manufacturors and customers, and colour measurement (Delta E).

Oak	best				>>>				worst
Overall	2	>	3	>	4	>	1	>	5
Contrast	2	>	4	>	1	/	3	/	5
Clarity	2	>	1	>	3	/	4	>	5
Delta E	2 (1.7)		1 (2.2)		4 (4.3)		5 (4.5)		3 (6.3)

Table 8. Cherry panels, evaluation for overall impression, contrast and clarity by a panel of furniture and paint manufacturors and customers, and colour measurement (Delta E).

Cherry	best				>>>				worst
Overall	4	/	1	/	2	>	5	>	3
Contrast	4	>	2	/	5	/	1	>	3
Clarity	2	>	4	/	3	/	5	>	1
Delta E	2 (1.8)		1 (3.2)		4 (5.9)		3 (7.1)		5 (9.5)

As can be seen from the tables 3 till 8, the correlation between the results from the visual assessment by the panel of manufacturors and customers and the colour measurement is much less than it was for the researchers panel and the colour measurement.

Apparently there is a different way of assessing the phenomena of Anfeuerung and different aspects thereof in the market than there is at the laboratory. This makes it very difficult to develop a suitable objective method for classifying wooden panels for Anfeuerung.

Nevertheless the effect of variation of coating formulation was studied using colour measerement.

3.3 Effect of coating formulation

3.3.1 Change of pH

Figure 1 shows the panels.

Figure 1. Panels change of pH, topdown beech panel, oak panel and cherry panel.

Figure 2 shows the change in Delta E for each pH for all three wood species. The visual assessment of the panels gave an equal result for all four pH values. Differences in Delta E values are relatively small and might be influenced by the decreasing viscosity of the formulations with increasing pH value. The viscosity change was not corrected before applying the formulations and therefore wetting of the wood and levelling of the coating were slightly influenced with changing pH.

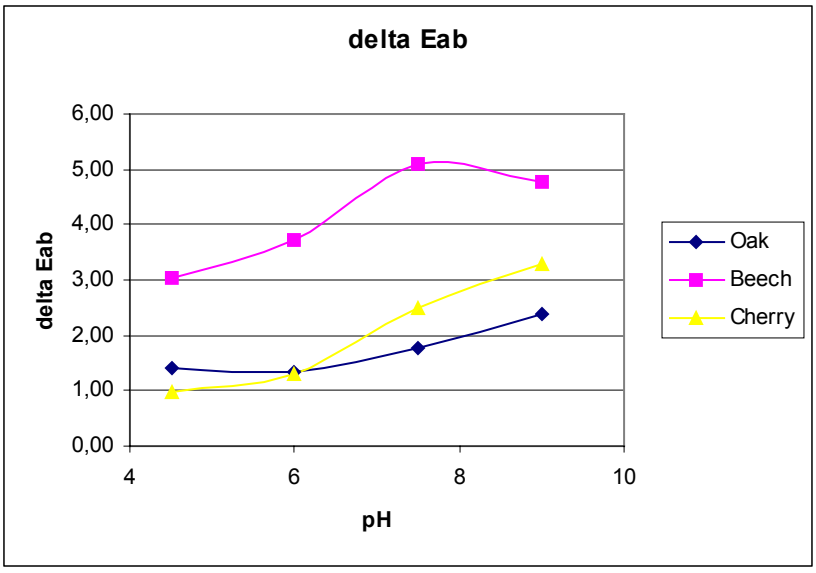

Figure 2. Delta E for different pH values.

3.3.2 Change of NCO/OH ratio

The visual assessment of the panels resulted in an equal evaluation for all four NCO/OH ratios. Differences in Delta E values are small and might be influenced by the increasing amount of cosolvent and isocyanate with increasing NCO/OH ratio. The measured Delta E values do not match the visuall assessment. For the beech an the cherry panel a much higher Delta E value is measured for the NCO/OH ratio of 40. This difference could not be seen visually on these panels. Figure 3 shows the Delta E for all four NCO/OH ratios for each wood specie.

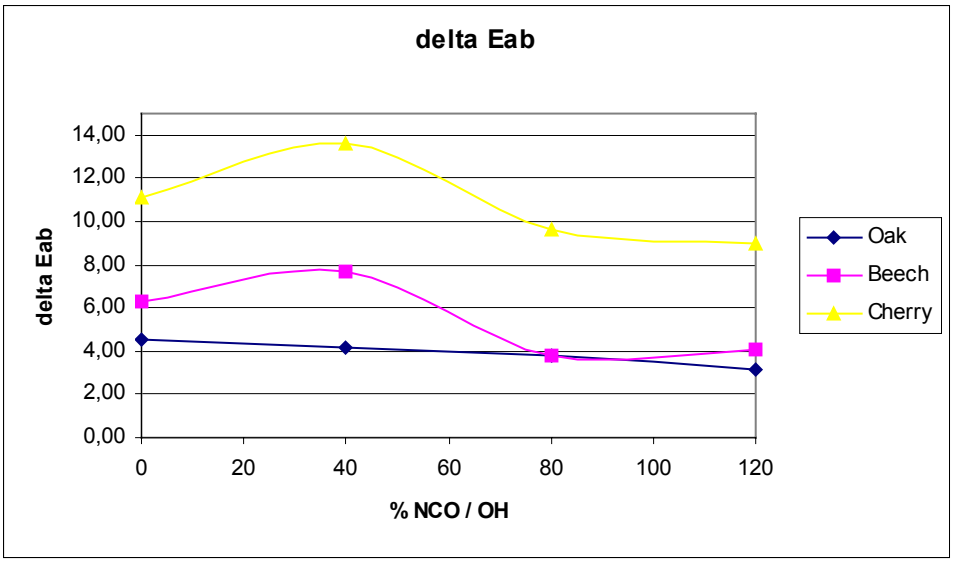

Figure 3. Delta E for different NCO/OH ratios

4. Conclusions

Our interpretation of literature indicated colour measurement on coated and wetted wood to be the most practical approach to discriminate coatings with good Anfeuerung from coatings with less Anfeuerung characteristics.

The visual assessment by the researchers panel and the colour measurements of a first series of 5 coatings on three wood species resulted in more or less the same order of coatings for Anfeuerung on all three wood species. Overall impression on Anfeurerung was dictated by the colour impressinon more than by contrast evaluation of the samples.
This was a nice result to carry on with further experiments.

This test series of 5 coatings showed also that on different wood species the different coatings are evaluated differently by visual assessment by the panel of furniture and paint manufacturors and customers and did not correlate with the colour measurements and the visual assessment by the researchers panel. Most remarkable is the fact that the ‘market-panel’ preferred a waterborne product on cherry above the NC laquer!

The second test series for differences in pH and NCO/OH ratio showed some uncertainties about reproducebility. Apparently, and especially on beech, after wetting with water the colour of the wetted wood changed so steadily to a darker colour that it influenced the measurement due to the time interval between two measurements.

Furthermore, variations in coating formulation might lead to such small effects on Anfeuerung that colour measurement alone does not discriminate accurately enough.
Other optical assessment will be needed to evaluate samples at another level for Anfeuerung.

Clearly for both change of pH and change of NCO/OH ratio more samples have to be prepared and evaluated to be able to exclude effects due to uncertainty of measurement and unwanted side effects from changes in coating formulation.

The method seems to be suitable for ordering coating formulations in classes of Anfeureung.
Most likely another optical method to evaluate clarity of the coating or contrast along with the colour measurement is needed to. Then it is a perspective method for screening waterborne alternatives for VOC products on their Anfeuerung characteristics.

Furthermore it is important that market parties and research come to an understanding of what is exactly meant by Anfeuerung. The variation in evaluation of the test samples by the market panel shows that there is no uniform perception of Anfeuerung in the market!

Future work

More coating formulations should be measured and assessed visually in greater series in order to confirm the reproducibility of the method. Also understanding and perception in the market of Anfeuerung has to be discussed with market and research parties.

The simple method should be optimised to reduce the chance for reproducibility failures. This optimisation might include an extra optical method for evaluating clarity or contrast.

Then the method might be useful for coating formulation development. It then offers an easy way for assessing the changes in colouration of wood by a variation in binder or additives and the effect on clarity or contrast thereof.

References

[1] Riemann, S. (1993) Entwicklungsstand der wässrigen Lackierung von Möbeln und Schreinerartikeln, Industrie Lackierbetrieb, Vol. 61, Nr. 8, pag. 291 – 294.

[2] Berkhout, L. and Baah, F. (2004) New Waterborne Polymer with Improved “Anfeuerung” for Medium/High Quality Wood Furniture, Advances in Coatings Technology ACT’04, 23-26 November 2004, Warsaw

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Appendix A Literature scan

Web search:

2004 (November) The coatings group – conference: b.v. Johnson Polymer, F. Baah, L. Berkhout: New waterborne polymer with improved “anfeuerung” for medium/high quality wood furniture.

Patent search:

Waterborne soft–feeling coating composition with high gloss (2K + alcohol alkoxylate) Patent number: US2004209983 (www.espacenet.com)

Congress papers:

1998 (19-21 October) Brussels, Belgium – Paper 27 Some possible defects of waterborne coatings for exterior use (Poor clearness of the film, milky appearance, micro bubbles, more mat and rough surface)

1999 (12-14 April) Nurnberg, Germany – Paper 33 An additives approach to defect elimination in thermoplastic waterborne industrial maintenance coatings (Airless, external micro foam cause loss of gloss) – Paper 43 The use of surfactants in waterborne wood finishes (Surfynol acetylenic glycol, poor wetting, foam control) – Paper 46 Investigation into the phenomenon of haze in clear matt waterborne coatings (silica matting agents – possible causes of haze)

2000 (23-25 October) The Hague, Netherlands – Paper 12 Film defects in waterborne coatings for exterior joinery (missing)

2001 (8-10 October) Basle, Switzerland, Rad Tech – Use of colloidal silica acrylates in UV coatings – Impact of size, size distribution and silica loading on film properties (also gloss)

2002 (28-30 October) The Hague, Netherlands – Paper 9 Two pack waterborne polyurethanes for furniture coatings (hydrophilic isocianate..., high gloss)

Articles:

Dombey S., Stangroom B., A comparative investigation of stains for wood, J. Oil Col. Chem. Assoc. 1980, 63 276-286.

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Appendix B Visual assessment by panel of manufacturors and customers

Table B1. Beech Overall impression

Beech	best				>>>				worst
1	2x	>	2x	>	1x	>	3x	>	6x
2	8x	>	4x	>	2x	>	0x	>	1x
3	1x	>	1x	>	3x	>	3x	>	4x
4	1x	>	2x	>	4x	>	4x	>	3x
5	1x	>	3x	>	4x	>	5x	>	1x
Overall	**2**	**>**	**4**	**/**	**5**	**/**	**3**	**>**	**1**
researcher panel	**2**	**>**	**1**	**>>**	**4**	**>**	**5**	**>>**	**3**
Delta E	**2 (2.7)**		**1 (5.7)**		**5 (7.6)**		**4 (9.5)**		**3 (10)**

Table B2. Beech Contrast

Beech	best				>>>				worst
1	0x	>	3x	>	3x	>	0x	>	6x
2	8x	>	3x	>	1x	>	0x	>	0x
3	3x	>	4x	>	1x	>	3x	>	1x
4	0x	>	0x	>	4x	>	4x	>	4x
5	1x	>	1x	>	3x	>	5x	>	1x
Overall	**2**	**>**	**3**	**/**	**4**	**/**	**5**	**>**	**1**
Researcher panel	**3**	**>**	**2**	**>>**	**1**	**>**	**4**	**>>**	**5**
Delta E	**2 (2.7)**		**1 (5.7)**		**5 (7.6)**		**4 (9.5)**		**3 (10)**

Table B3. Beech Clarity

Beech	best				>>>				worst
1	3x	>	3x	>	1x	>	0x	>	6x
2	5x	>	3x	>	1x	>	2x	>	1x
3	2x	>	2x	>	1x	>	5x	>	2x
4	2x	>	2x	>	2x	>	2x	>	3x
5	1x	>	1x	>	7x	>	3x	>	0x
Overall	**2**	**>**	**4**	**/**	**5**	**/**	**3**	**>**	**1**
Delta E	**2 (2.7)**		**1 (5.7)**		**5 (7.6)**		**4 (9.5)**		**3 (10)**

Table B4. Oak Overall impression

Oak	best				>>>				worst
1	3x	>	2x	>	3x	>	3x	>	4x
2	8x	>	1x	>	1x	>	3x	>	0x
3	2x	>	5x	>	3x	>	3x	>	1x
4	1x	>	3x	>	7x	>	0x	>	2x
5	0x	>	3x	>	0x	>	5x	>	6x
Overall	**2**	**>**	**3**	**>**	**4**	**>**	**1**	**>**	**5**
researcher panel	**2**	**>**	**1**	**>>**	**4**	**>**	**5**	**>>**	**3**
Delta E	**2 (1.7)**		**1 (2.2)**		**4 (4.3)**		**5 (4.5)**		**3 (6.3)**

Table B5. Oak Contrast

Oak	best				>>>				worst
1	2x	>	1x	>	3x	>	3x	>	3x
2	10x	>	0x	>	2x	>	0x	>	0x
3	0x	>	3x	>	1x	>	4x	>	3x
4	0x	>	5x	>	5x	>	2x	>	0x
5	0x	>	3x	>	1x	>	3x	>	5x
Overall	**2**	**>**	**4**	**>**	**1**	**/**	**3**	**/**	**5**
researcher panel	**2**	**>**	**4**	**>**	**1**	**>**	**5**	**>**	**3**
Delta E	**2 (1.7)**		**1 (2.2)**		**4 (4.3)**		**5 (4.5)**		**3 (6.3)**

Table B6. Oak Clarity

Oak	best				>>>				worst
1	4x	>	4x	>	1x	>	2x	>	2x
2	7x	>	3x	>	1x	>	1x	>	1x
3	2x	>	2x	>	4x	>	2x	>	3x
4	1x	>	2x	>	4x	>	6x	>	0x
5	0x	>	2x	>	3x	>	1x	>	7x
Overall	**2**	**>**	**1**	**>**	**3**	**/**	**4**	**>**	**5**
Delta E	**2 (1.7)**		**1 (2.2)**		**4 (4.3)**		**5 (4.5)**		**3 (6.3)**

Table B7. Cherry Overall impression

Cherry	best			>>>			worst		
1	4x	>	4x	>	1x	>	4x	>	1x
2	3x	>	4x	>	2x	>	1x	>	4x
3	3x	>	0x	>	4x	>	1x	>	6x
4	4x	>	4x	>	3x	>	2x	>	1x
5	0x	>	2x	>	4x	>	6x	>	2x
Overall	**4**	**/**	**1**	**/**	**2**	**>>**	**5**	**/**	**3**
Researcher panel	**2**	**>**	**1**	**>>**	**4**	**>>**	**5**	**>**	**3**
Delta E	**2 (1.8)**		**1 (3.2)**		**4 (5.9)**		**3 (7.1)**		**5 (9.5)**

Table B8. Cherry Contrast

Cherry	best			>>>			worst		
1	0x	>	4x	>	3x	>	3x	>	4x
2	2x	>	4x	>	3x	>	3x	>	1x
3	0x	>	0x	>	1x	>	5x	>	6x
4	9x	>	1x	>	2x	>	0x	>	0x
5	1x	>	3x	>	4x	>	1x	>	1x
Overall	**4**	**>**	**2**	**/**	**5**	**/**	**1**	**>**	**3**
Researcher panel	**2**	**>**	**1**	**>>**	**4**	**>**	**3**	**>**	**5**
Delta E	**2 (1.8)**		**1 (3.2)**		**4 (5.9)**		**3 (7.1)**		**5 (9.5)**

Table B9. Cherry Clarity

Cherry	best			>>>			worst		
1	1x	>	1x	>	3x	>	3x	>	3x
2	5x	>	1x	>	0x	>	4x	>	2x
3	3x	>	1x	>	3x	>	2x	>	3x
4	2x	>	6x	>	3x	>	2x	>	0x
5	0x	>	3x	>	3x	>	2x	>	4x
Overall	**2**	**>**	**4**	**/**	**3**	**/**	**5**	**>**	**1**
Delta E	**2 (1.8)**		**1 (3.2)**		**4 (5.9)**		**3 (7.1)**		**5 (9.5)**

Appendix C Change of pH – Extra data.