Advanced LC Mixture Concept of Improved Response Time

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Abstract

Improvement of LC mixtures can be realized by the development of new molecules in combination with the identification of advanced mixture concepts. By new high-polar single materials rotational viscosity has recently been improved significantly. Now, a new LC mixture concept for IPS and FFS technology has been identified which additionally improves switching time by up to 10%. This advanced concept is based on a more efficient usage of high-polar materials and Super Low Viscous (SLV) compounds and simultaneous reduction of less efficient materials.

1. Introduction

Development of liquid crystal displays (LCDs) has made remarkably advances over the last years, resulting in today's state-of-the-art LCDs of high performance. This evolution towards present high-end LCDs was assisted by the development of LC mixtures being characterized by a steady as well as significant improvement of physical properties [1,2].

While the development of fast LC mixtures has turned out to be an important factor for display performance, it is mainly based on two correlated approaches: (1) the realization of efficient LC mixture concepts taking advantage of the different properties of single materials involved and (2) the identification and synthesis of new molecular structures.

Hence, efficient LC development strategy targets not only the identification of new molecules and the introduction of advanced LC mixture concepts separately, but their simultaneous design, allowing for the most pronounced response time improvement.

2. Advanced Mixture Concept

Years ago, LC mixtures were mainly based on the usage of materials being characterized by a homogeneous distribution of different polarities.

Due to the development of new molecular structures in combination with an extreme high quality level in the last years, more effective LC mixtures became available, resulting in today's high-performance liquid crystal mixtures.

For the time being, modern LC mixture concepts make use of a strategy which combines efficient high-polar substances with so-called Super Low Viscous (SLV) materials. This modern concept is characterized by a very low rotational viscosity and fast response time respectively [3].

This approach has now further been improved by an advanced concept based on an optimised combination of LC single material classes. This optimization was achieved by the reduction of single materials with medium and low extrapolated clearing point, while concentration of high-polar materials with high clearing point was increased. By this, medium polars were reduced and SLV fraction was enhanced.

As a result, simulations as well as measurements show that $\gamma 1$ of state-of-the-art concepts can additionally be improved by up to 10% without any new single material. In addition, high-polar single materials can be used more effectively and range of modern concepts can be extended to lower polarity at higher efficiency.

3. Efficiency of high-polar LC single materials

As LC mixtures with fast response times are generally based on modern concepts combining high-polar single materials with Super Low Viscous (SLV) compounds, Merck recently introduced new efficient high-polar molecules [3]. These materials exhibit a very good combination of high polarity with high clearing point. While they clearly improve response times of LC mixtures in the medium and high polar range, benefit is limited for targets of lower polarity. Therefore, current modern concepts are mainly advantageous at sufficient high polar targets.

The new mixture concept now enables the extension of efficient usage of high-polar single materials to a broader mixture polarity range. These results can nicely be seen from Table 1.

75°C / 0.10 / 7.5	Previous Concept	Previous Concept	Improved Concept
High-Polar Single Material [%]	-	8	12,5
SLV Material [%]	28	33	41,5
g1 [mPas]	61	59	55

Table.1. Example for enhanced efficiency of high-polar single materials usage. These materials are of limited benefit within previous concept for Δε=7.5. New mixture concept results in a significant improvement of rotational viscosity.

The example shows that the usage of modern concepts based on high-polar materials in combination with SLV compounds only improves rotational viscosity by 2 units. On the other hand, if the high-polar single material is used within the new advanced concept, a more efficient concentration is accessible. In addition, the amount of SLV material can be increased, resulting in a reduction of rotational viscosity by additional 4 units.

While this low rotational viscosity can not be realised by the new concept or the new high-polar material alone, it shows the importance of a combined strategy of (1) efficient LC mixture concepts taking advantage of the different singles materials involved and (2) the identification and synthesis of new single molecules.

3.1. Efficiency of high-polar LC single materials for TV application

Beside monitor application, the market demands faster response time for next generation of TV application as well. Since IPS TV with 5ms gray-to-gray (GtG) response time is already in the market, the next target would be considerably under GtG 5ms. The state of the art LC mixtures for GtG 5ms exhibit rotational viscosity of round 61-63 mPas depending on corresponding mixture specification. Since the polarities of mixtures for TV application are in moderate range between Δε=7-7.5 the new Improved Mixture Concept would be applicable.

For next generation of TV with <5ms switching time new innovative mixture concept is required, which leads to LC mixtures with rotational viscosity value clear <60. (Figure 1)

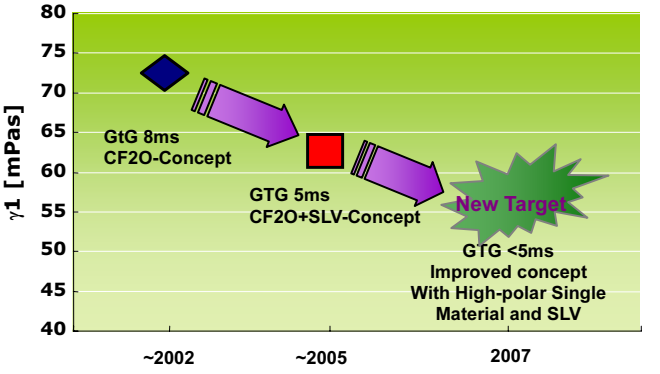

Fig.1. Trend of TV application in recent years in terms of response time. To achieve GtG under 5ms rotational viscosity of significant fewer than 60 mPas is required.

We developed new LC mixtures applying hereby-introduced Improved Concept. The optimized concentration of new high-polar single material, up to 15%, allows usage of increased amount of SLV single material. Consequently we could achieve rotational viscosity value of 56 mPas. (Table 2)

It is expected, that with the new mixture concept the next generation of TV application with GtG <5ms could be achievable.

75°C / 0.10 / 7.5	LC mixture with Previous Concept	LC mixture with Improved Concept
High-Polar Single Material [%]	-	15
SLV Material [%]	30	40
γ1 [mPas]	63	56

Table.2. Example for enhanced efficiency of high-polar single materials usage in combination with SLV material for TV application

4. Improvement of modern LC mixtures

Besides this extension of the usable range of high-polar single materials within modern concepts, the efficiency of state-of-the-art concepts is further improved. While modern concepts have already clearly reduced rotational viscosities, further improvement is achieved by the new advanced mixture strategy.

Fig. 2 shows measurement results for a broader range of polarities, ranging from dielectric anisotropy Δε of 6 up to 11.

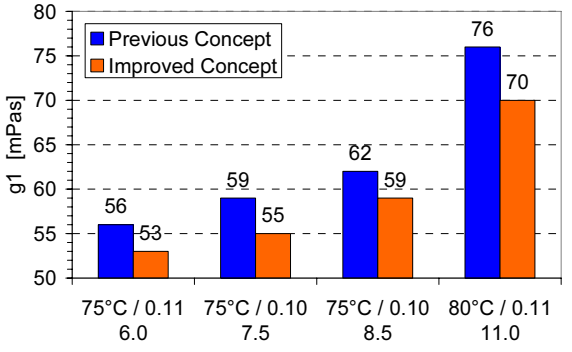

Fig.2. Improvement of rotational viscosity resulting from new LC mixture concept for different Δε = 6.0, 7.5, 8.5 and 11.0. The improvement holds for all T_{Clp} / Δn shown.

As can be seen from these data, previous concepts based on high-polar materials in combination with SLV compounds can further be improved by the new advanced mixture concept. This holds for an extended range of dielectric anisotropy as well as for different values of the optical birefringence.

As reliability aspects are one of the most important issues for LC mixture development, the high-polar materials within the new concept were intensively studied w.r.t. its impact on quality. In sum, molecular structural design, modern LC production technology as well as the reduction of less favorable materials by the new concept allow high reliable LC mixtures. For this, LC mixtures comprising this new concept keep high quality level of state-of-the-art LC mixture technology.

5. Summary

While modern LC mixtures take advantage of a combination of high-polar materials with Super Low Viscous (SLV) compounds, further switching time improvement was achieved by the design of an advanced mixture concept. It is based on a more efficient usage of high-polar LC materials and their combination with SLV compounds. In addition, the new concept allows a reduction of the amount of less efficient materials. As a result, high-polar single materials are used more effectively. The range of response time improvement by high-polar molecules is extended towards targets of lower dielectric anisotropy. The rotational viscosity is improved by up to 10% and a significant improvement of switching time is achieved. Furthermore, by the simultaneous reduction of less favorable molecular structures, the new LC mixtures exhibit a high level of reliability.

In sum, usage of recently introduced high-polar single materials in combination with SLV compounds within new concept results in the best overall performance.

6. References

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