

Table of contents

1 Introduction.....	7
2 Theory – State of Research.....	8
2.1 Autoxidation	8
2.2 Thermal oxidative ageing	9
2.3 Radical stability.....	9
2.4 Reaction mechanisms used for explanation from the literature	10
3 Utilised fuels	12
3.1 Biodiesel	12
3.2 Hydrogenated vegetable oil (HVO)	13
3.3 Polyoxymethylene dimethyl ether (OME).....	13
4 Measurement and evaluation methods used and sensor details	14
4.1 Accelerated artificial ageing	14
4.1.1 Rancimat method	14
4.1.2 Petrooxy method.....	15
4.2 Fourier transform infrared spectrometry (FTIR)	15
4.3 Near infrared spectroscopy with laboratory measuring device.....	15
4.4 Partial least squares Regression (PLS)	15
4.4 Liquid chromatography coupled mass spectrometry.....	16
4.5 Spectroscopic methods of the developed sensor technology	17
4.5.1 Dielectric sensor	19
4.5.2 Optical sensor	20
5 Evaluation of the mass spectrometric investigations	22
5.2 Chromatographic separation.....	22
5.3 Structure elucidation of the ageing products with MS/MS fragmentation pattern	23
6 Ageing tests by RME	26
6.1 Overview of the ageing test	26
6.2 Identified ageing products and statements about the underlying mechanisms	27
6.2.1 Simple oxidation products.....	27
6.2.2 Multiple oxidation products.....	33
6.2.3 Short-chain degradation products	36
6.2.4 Dimerization	37
6.2.5 Acids	42
6.3 Time course of RME ageing	44
6.3.1 Starting products	46
6.3.2 Simple oxidation products.....	46

6.3.3 Twofold oxidation products	46
6.3.4 Triple oxidation.....	47
6.3.5 Fourfold oxidation	49
6.3.6 Short-chain degradation products	49
6.3.7 Dimer formation	50
6.4 Influence of the fuel composition on the ageing behaviour	50
6.4.1 Simple oxidation	52
6.4.2 Double oxidation	54
6.4.3 Triple oxidation.....	54
6.4.4 Fourfold oxidation	55
6.4.5 Short-chain degradation products and acids	56
6.4.6 Influence of the volume fraction of RME	57
7 additive tests	59
8 Developed fuel sensors	64
8.1 Empirical variance and measurement accuracy of the developed sensors	65
8.1.1 Dielectric measurements (permittivity and conductivity)	65
8.1.2 Optical measurements (near infrared, fluorescence and VIS spectroscopy)	67
8.2 Fluorescence measurement data	70
8.3 Determination of the fuel composition and the degree of ageing	71
8.3.1 Partial Least Square evaluation	71
8.3.2 Fuels used	72
8.3.3 PLS evaluation using reference analysis	73
8.3.4 Sensor-based prediction.....	79
9 Summary.....	84
10 Outlook.....	85
11 Bibliography.....	86