

*dialysis monitoring, urea,
spectrophotometry.*

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REMARKS ON SPECTRA-PHOTOMETRIC MONITORING OF UREA IN DIALYSATE

The authors try to explain why the direct, spectra-photometric examination of urea content in dialysate is practically ineffective (in UV-VIS range of spectrum) despite the fact that, in general, spectra-photometry is valuable and very sensitive method of chemical composition determination. An attempt was made to prove that spectra-photometric monitoring of urea dialysis, in chosen parts of UV-VIS spectrum, can be achieved only through indirect measurements.

1. INTRODUCTION

Healthy organism eliminates useless substances continuously without any problems and in the best possible way. But in many diseases related to renal dysfunction there is a need of extra somatic elimination of more or less toxic products of metabolic processes (e.g. urea or creatinine) and redundant constituents like water or some ions [5]. Dialysis efficiency is usually estimated from the results of blood analysis, which for obvious reasons, is usually performed after any session. Therefore any decisions about modifications in the course of dialysis are usually made only when some other symptoms in a patient's state occur. On-line monitoring of the substances removed with the effluent dialysis could make these modifications more accurate and on time. For technical reasons but also of cost considerations usually one substance is chosen for on-line analysis. It must be such a substance which well represents also the removal of other substances in the process of dialysis. Urea is usually chosen as a marker for renal function and therefore also for monitoring of dialysis progress [6]. The efficient but rather complex method of urea measurements in dialysed urea is based on conductivity measurements. Urea's enzyme added to the sample reacts with urea and the products of this reaction can be detected with a conductivity sensor.

Though monitoring of urea concentration in dialysed by spectra-photometric method is often discussed in recent literature and despite of the undisputable sensitivity of the spectra-photometric methods widely used in chemical composition analysis [4], the authors of this work found some serious limitations of this approach. The authors explain the encountered

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difficulty and show that indirect spectra-photometric measurements of urea content in spent dialysis are still possible in some parts of UV-VIS range of wavelengths.

2. MODEL OF THE MEASURING SETUP

The scheme of the system for spectroscopic determination of the effluent dialysis composition is presented in Fig.1. Its most important part is a two beam spectrophotometer. The flux of the effluent dialysis in the equipment passes through the measuring beam while the reference beam goes through unused, pure dialysis. The result of the measurement, that is the transmission of dialysed product with a waste remaining relative to pure dialysed urine can be continuously recorded in computer's memory or followed on the screen.

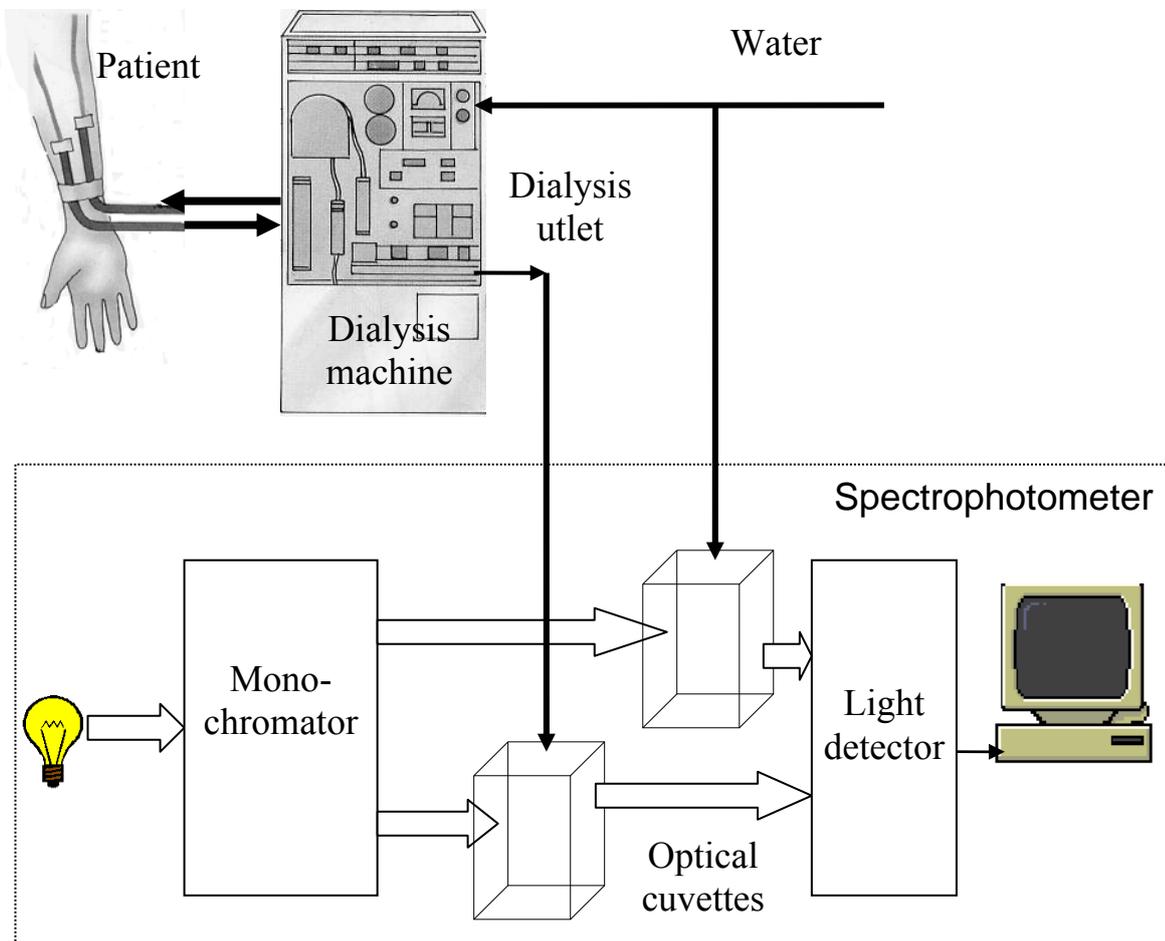


Fig. 1. The scheme of the system for on-line spectroscopic determination of the effluent dialysate composition.

3. RESULTS OF THE MEASUREMENTS

It was assumed that the concentration of urea in blood is usually less than 2g/l; that the volume of dialysis product for one session is about 200 litres and that blood volume is four litres. The averaged concentration of urea in used dialysis estimated from such assumptions is about several hundredths of grams per litre. Then the solutions of pure urea in distilled water were prepared with the following concentrations: 2.5, 5, 10, 20, 40, 80 mg/l. Transmission of light for these samples in relation to the transmission of distilled water was measured with UV-VIS spectrophotometer in the range of wavelengths 190-800 nm. The results are presented in Fig.2. The range of wavelengths in Fig. 2 ends at 220 nm because for the higher wavelengths transmission was one hundred percent. It means that urea does not absorb above 220 nm.

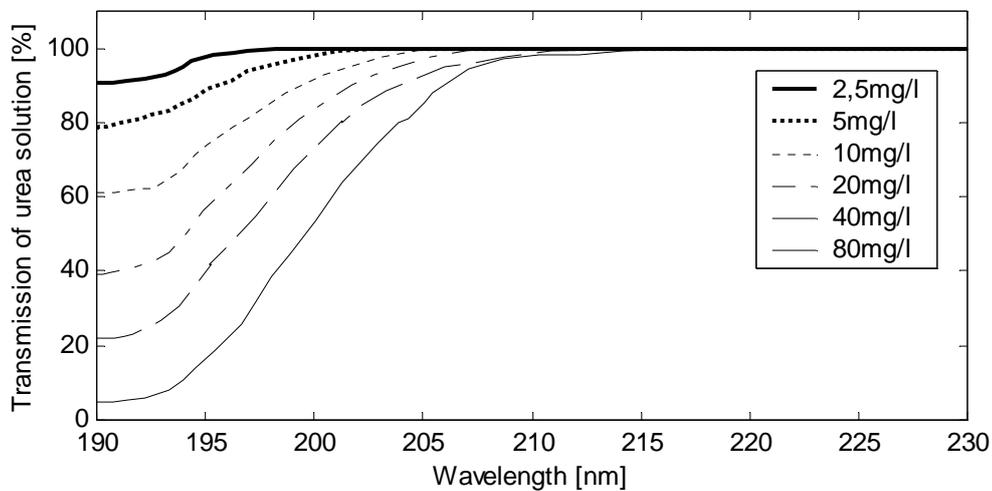


Fig. 2. Transmission spectrum of urea dissolved in water versus the wavelength of light. Different lines represent the data for the samples of different concentrations i.e.: thick solid 2,5mg/l , thick dotted line 5mg/l , dotted line 10mg/l , dash-dot 20mg/l, dashed line 40mg/l , solid line 80mg/l .

Conclusions from the analysis of these results are as follows: urea exhibits measurable absorption only below 200 nm and for the concentrations of interest (2-80mg/l) this absorption can be used for qualitative measurements. The last conclusion is even clearer when the data from Fig.2 are presented in another form – Fig.3.

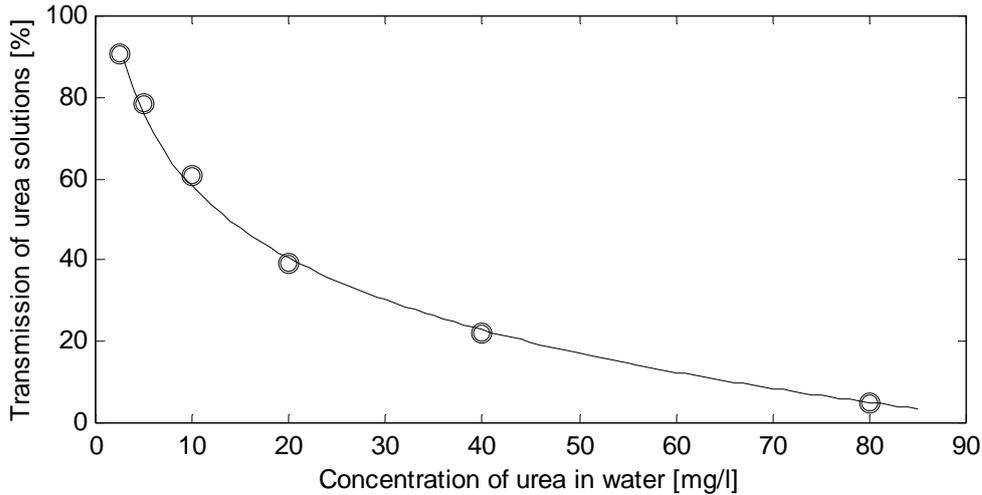


Fig. 3. Transmission of water solution of urea for the light wavelength 190nm versus urea concentration.

Unfortunately, the same experiment repeated for urea solutions not in water but in the dialysis product did not give similar results. What we found was that the transmission of urea dissolved in the dialysis relative to pure dialysis is practically independent of concentration, even up to 160 mg/l.

This strange result can be explained on the basis of transmission data of the pure dialysis product relative to distilled water presented in Fig.4.

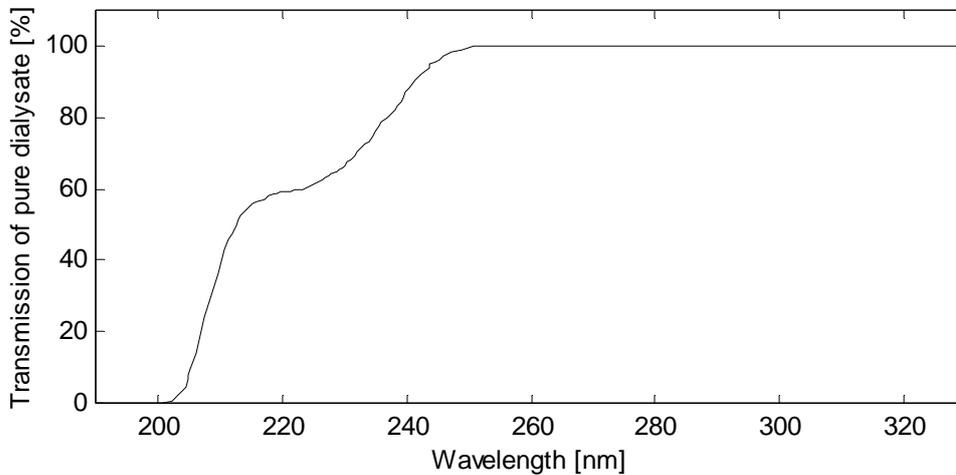


Fig. 4. Transmission of pure dialysis product as a function of wavelength.

The next measurements of transmission versus the wavelength were conducted for the dialysis samples collected in a clinic during the real session of haemodialysis. The samples for measurement were taken from the outlet of the used dialysis product, the first after 5 minutes and the rest after 1, 2,3 and 4 hours from the beginning of the dialysis. The results are presented in Fig.5 for the samples from one of several examined patients (there were no significant, qualitative differences from one patient to another).

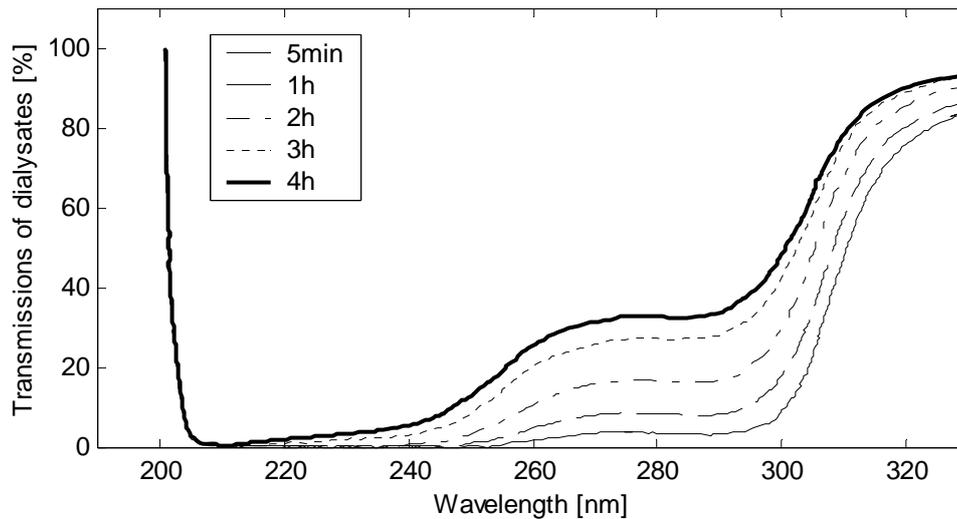


Fig. 5. Transmission of effluent dialysis as a function of wavelength

These data for real haemodialysis confirm the earlier conclusion made on the basis of the measurements for laboratory prepared samples. There is no dependence on the urea concentration which should manifest itself in the range 190-200 nm. Instead, the curves have other interesting features. Between 250nm and 310 nm there is the significant change of transmission during the session. Absorption in this range of wavelengths, as proved above, does not result from urea itself, but must be connected with other substances also eliminated from the patient's blood by dialysis. One must be aware, that any conclusions about urea content in the dialysis and its removal from the patient's blood are possible only indirectly, because of the correlation with other substances.

4. CONCLUSIONS

A dialyser membrane has different filtration rate for molecules of different compounds and for this reason concentrations of these substances, both in blood and in the dialysis do not change according to one pattern. Their removal rates are, for sure, correlated in pairs but this correlation may vary from one pair to another [2,3]. Moreover, this can be influenced by many different factors e.g. initial concentrations in patient's blood or the type of the dialyser membrane. The conclusion can be drawn from the presented work, that for monitoring of haemodialysis different markers can be used and that urea is not the perfect choice. The wavelength for the spectra-photometric analysis of dialysed urine ought to be chosen in the range 260-300 nm.

Further investigations for many patients are required to find quantitative results for all waste substances removed by the dialysis process.

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The authors express gratitude to Professor M. Nowicki and dr J. Fijałkowska – Morawska from Medical University of Łódź for their help in the medical aspects of this work.

The work was financed from the grant KBN T11E 02925.