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Scientific article

Counterfeit identification documents of the European Union Member States: forensic characterization of polymers and determination of individualization methods

Jasna Galeković, Veronika Marinović, Andrea Ledić

Forensic Science Centre "Ivan Vucetic", Ministry of the Interior,
Ilica 335, 10000 Zagreb, CROATIA
Correspondence: vmarinovic@mup.hr

Abstract:

Modern identification and travel documents, such as identity cards, driver's licenses and residence permits, are made of polymers. European Union (EU) regulations stipulate that security documents issued by EU Member States (EU MS) in ID-1 (card) format shell be made of polycarbonate (PC) or an equivalent synthetic polymer, which can last at least 10 years. Due to the wide range of temperature resistance, polycarbonate documents can be individualized by laser engraving, which is considered as one of the most reliable ways of integrating the owner's data and image into the body of the polycarbonate cards. Until recently, various printing techniques, such as thermal printing, laser or inkjet printing, have been used for the individualization of counterfeit travel and identity documents made of polymers. However, in recent times, a new form of forgery of documents made of polymers has appeared, on which the bearer's photo and data are laser-engraved, as is the case with legally issued documents made of polycarbonate.

In the present study, 82 samples of different types of counterfeit EU MS documents made of polymer were analysed (identity cards, driving licenses, residence permits), using non-destructive methods. IR-spectroscopy with ATR technique was used for the analysis of the qualitative chemical composition of the polymer of counterfeit documents. Video-spectral and stereomicroscopic analysis were used for the determination of techniques used for the production and individualization of counterfeit documents.

This study will show that the technique used to individualize polymer counterfeit documents depends on the type of polymers used.

Keywords:

identity documents, counterfeit documents, polymers, polycarbonate, IR-spectroscopy, laser engraving

1. Introduction

The use and possession of polymer cards have become routine in today's modern society as individuals possess polymer cards for a variety of purposes, which include identity cards (ID cards), bank cards, driving licenses, residence permits, healthcare cards, security access cards etc. [1]. Some of these polymer cards can be used by means of proving identity, obtaining passports and visas or accessing various financial services, and are therefore a frequent target for counterfeiting and represent significant security and economic

threats at the European and international level. Documents in card format used for personal identification in the EU Member States (EU MS) are identity cards, residence permits and driving licenses. According to European Union regulations , polymer travel and identification documents issued in card format shell be made entirely of polycarbonate (PC) or an equivalent synthetic polymer (lasting for at least 10 years). The majority of travel and identification documents of EU MS are made of polycarbonate (PC), while individualization is carried out using the laser engraving technique [2, 3]. Until recently, various printing techniques, such as thermal printing and laser and inkjet printing, were used to individualize counterfeit travel and identification documents made of polymer. In recent times, a new form of counterfeits has appeared, on which the bearer's photo and data are laser engraved, as is the case with legally issued documents made of polycarbonate. The verification of the authenticity of polymer identity cards, residence permits and driving licenses, which is carried out by police officers, mainly at the first and second line border control, relies on a visual inspection of the documents and their security features and also on the technique used for the individualization of those documents. The training of the examiners thus plays a big role in the possibility of detecting counterfeit documents of a god quality. The most laser engraved counterfeit documents have imitated security features of a high-quality, which can be very challenging for law enforcement officers conducting documents control and can lead to the wrong conclusion so counterfeit polymer documents can remain undetected. Identification of polymers can also be one of the evidence when examining polymer documents. A reliable, simple and non-destructive tool for chemical screening would be of a great value in the fight against counterfeiting of polymer travel and identification documents.

FTIR-ATR method is suitable for the characterization of polymers of counterfeit documents because it is reliable, non-destructive (does not require sample preparation), gives an IR spectrum of high chemical value and is easy to use. Papers is published in which IR spectroscopy with the ATR technique was used to determine the chemical composition of polymer driving license cards from Western Australia [4, 5]. In addition, the paper is published in which FTIR-ATR method was used as the examination method for the chemical composition of polymer cards of three residence permits of one EU MS [3]. Various studies have demonstrated the use of FTIR-ATR method for the characterization of polymer-based products, such as food packaging films [6], textile fibres [7, 8] and automotive paints [9].

However, according to our knowledge, the use of FTIR-ATR method for the characterization of polymers of counterfeit personal documents (ID cards, driving licenses and residence permits) of different EU MS has not been previously published in the available literature, neither the correlation between different types of polymers used for the production of counterfeit document and the technique used for their individualization.

In this paper, the FTIR-ATR method was used to characterize the polymers of counterfeit documents of several EU MS, together with a video-spectral and stereomicroscopic analysis used for the determination of techniques used for the individualization process on counterfeit documents.

The aim of the paper

The aim of this study is to analyse the types of polymers used in the production of counterfeit personal documents in ID-1 format within the EU and to identify the techniques applied for their individualization. The study seeks to establish a correlation between the polymer types and the individualization methods, providing valuable insights for the forensic community.

2. Materials and methods

2.1. Collection and preparation of samples

The polymer documents analysed in this paper are part of the Collection of genuine and forged documents of the Forensic Science Institute "Ivan Vučetić". Seventeen (17) genuine documents (specimens), issued by thirteen (13) EU MS, were analyzed, of which nine (9) specimens are identity cards, four (4) specimens are driving licenses and four (4) specimens are residence permits. Eighty-two (82) counterfeit polymer documents in ID-1 (card) format from thirteen (13) EU MS were analysed, as follows:

- counterfeit identity cards: 53 samples (9 EU MS)
- counterfeit driving licenses: 15 samples (4 EU MS)
- counterfeit residence permits: 14 samples (4 EU MS)

Chemical analysis of polymer cards using the FTIR-ATR method does not require any sample preparation other than card cleaning. Before analysis, each card was thoroughly wiped on both sides using a tissue soaked in 70% ethanol to remove impurities from the card surface.

2.2. Analytical equipment

2.2.1 FTIR spectrometer with ATR technique (FTIR-ATR)

The chemical analysis of the polymer cards was performed using the non-destructive FTIR-ATR method. IR spectra were recorded using a FTIR spectrometer (Bruker, model Tensor 27, Germany) equipped with an ATR accessory (DuraSampleIR with diamond crystal and press). Measurements were performed in the range of 4000-650 cm-1 in transmittance mode, with a resolution of 4 cm-1 and 10 scans. Data acquisition was performed using Opus software (version 4.2) with a background air spectrum recorded before each sample. The polymer card was placed on the ATR crystal so that it covers the surface of the crystal and solid contact between the card and the ATR crystal is achieved with a press that, after placing the card on the crystal, turns clockwise to the end position, and then starts recording the sample. IR spectra were collected from both sides of polymer cards (recto and verso).

2.2.2 Video-spectral comparator

The video-spectral comparator is an essential tool in the field of Questioned Document Examination (QDE) and is commonly used for the non-destructive analysis of documents using combination of different light sources (direct, transmitted, oblique, coaxial, etc.), filters and different wavelengths of the electromagnetic spectrum (white light, ultraviolet, infrared). Using video-spectral comparator (model VSC-6000/HS, Foster + Freeman, UK), it was possible to determine the authenticity of polymer documents. The video-spectral comparator was used for examination of imitated security features on counterfeit documents.

2.2.3 Stereomicroscope

A stereomicroscope is an optical instrument used to determine the techniques of individualization of polymer documents (model Leica M205C, Leica Microsystems, Germany).

3. Results and Discussion

3.1. FTIR-ATR, video-spectral and stereomicroscopic analysis of genuine and counterfeit polymer documents of EU MS

Using video-spectral and stereomicroscopic analysis and the FTIR-ATR method, genuine polymer documents (specimens of identity cards, driving licenses and residence permits of EU MS) and counterfeit polymer documents (identity cards, driving licenses and residence permits of EU MS) were analysed.

The EU MS from which the counterfeit documents originate are marked in alphabetical order as EU MS 1 - EU MS 13.

3.1.1. FTIR-ATR, video-spectral and stereomicroscopic analysis of identity cards

The FTIR-ATR method was used to perform a chemical analysis of the polymer of the polymer identity cards (ID cards) specimens from nine (9) EU MS in card format and the polymer of fifty-three (53) counterfeit polymer ID card specimens from nine (9) EU MS in card format, with the aim of determining the type of polymer. It was determined that the polymer ID card specimens from EU MS were made of polycarbonate (PC), while the counterfeit ID cards were made of other types of polymers, namely thirty-four (34) of them were made of polymethylmethacrylate (PMMA), sixteen (16) of polyethylene terephthalate (PET) and three (3) of polyvinylchloride (PVC).

Using stereomicroscopic analysis, it was determined that the ID card specimens were individualized by laser engraving. Counterfeit ID cards made of PET are individualized by inkjet (14) or thermal printing (2), while ID cards made of PVC (3) are individualized by inkjet printing. Individualization by laser engraving is present on seven (7) counterfeit ID cards made of PMMA (Figure 1), while other twenty seven (27) were individualized by thermal printing.

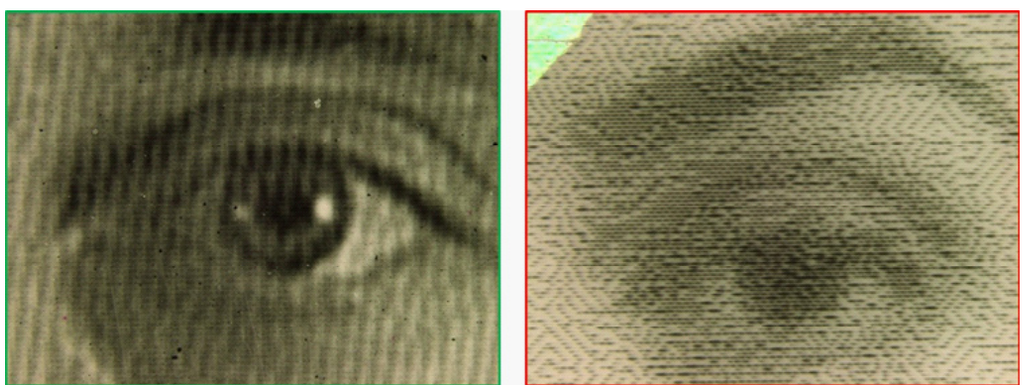

Figure 1. Laser engraving on genuine (left) and counterfeit (right) identity card (ID-card).

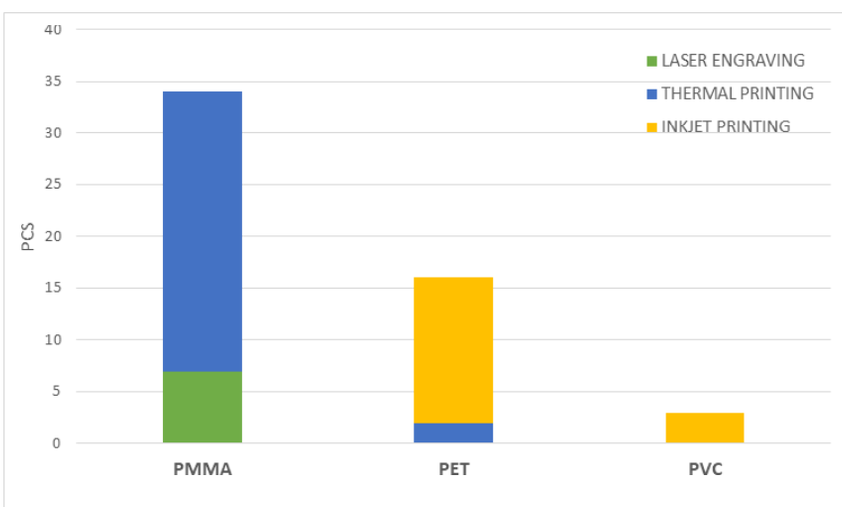

Figure 2. Correlation between polymer type and individualization techniques on counterfeit EU MS identity cards.

Using video-spectral analysis it was determined that on laser engraved counterfeit ID cards made of PMMA lots of first level security features has been imitated, such as diffractive optically variable image devices (DOVID), optically variable ink (OVI), rainbow colours etc.

The correlations between polymer type and individualization techniques on counterfeit EU MS identity cards (ID cards) are shown in Figure 2.

3.1.2. FTIR-ATR, video-spectral and stereomicroscopic analysis of driving licenses

Using the FTIR-ATR method, a chemical analysis of polymer samples of driving licenses in card format from four (4) EU MS and polymers of fifteen (15) forged driving licenses in card format from four (4) EU MS was carried out, with the aim of determining the type of polymer.

It was found that the driving licenses specimens were made of polycarbonate (PC) polymer, while the counterfeit polymer driving licences were made of other types of polymers, namely:

eleven (11) counterfeit driving licenses were made of PMMA,

two (2) of PET and two (2) of PVC.

Stereomicroscopic analysis revealed that the driving license specimens are individualized by laser engraving.

Counterfeit driving licenses made of PET (2) and PVC (2) are individualized by inkjet printing. Individualization by laser engraving (1) or thermal printing (10) is only present on counterfeits made of PMMA.

Through video-spectral analysis, it was determined that counterfeit driving licenses made of PMMA have numerous imitated security features.

The correlations between polymer type and individualization techniques on counterfeit EU MS driving licenses are shown in Figure 3.

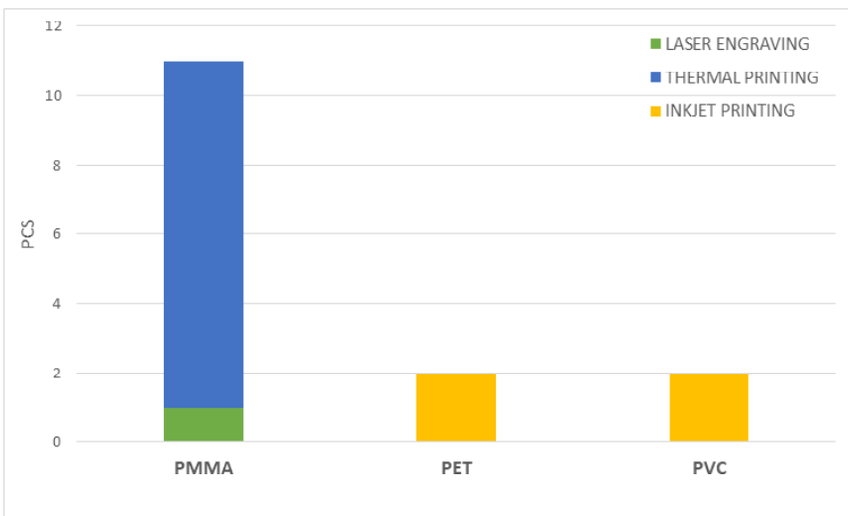

Figure 3. Correlation between polymer type and individualization techniques on counterfeit EU MS driving licenses.

3.1.3. FTIR-ATR, video-spectral and stereomicroscopic analysis of residence permits

Using the FTIR-ATR method, a chemical analysis of polymer samples of polymer residence permits in card format from four (4) EU MS and polymers of fourteen (14) counterfeit polymer residence permits in card format from four (4) EU member states was carried out in order to determine the type of polymer. It was found that the polymer

residence permit specimens were made of polycarbonate (PC), while thirteen (13) counterfeit residence permits were made of PMMA, and one (1) counterfeit residence permit was made of PET.

(3) or thermal printing (10) is present only on counterfeits made of PMMA.

Video-spectral analysis revealed that on the counterfeits made of PMMA imitated security features are of a good quality (Figure 4).

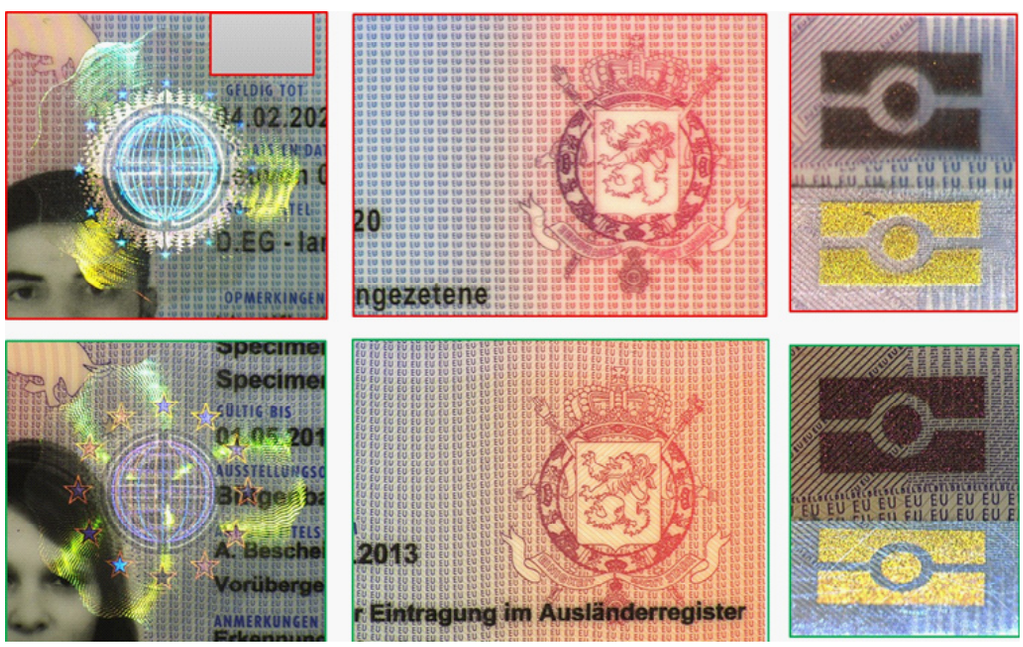

Figure 4. Imitation of security features on counterfeit residence permits (marked in red) and security features on genuine residence permits (marked in green).

The correlations between polymer type and individualization techniques on counterfeit EU MS residence permits are shown in Figure 5.

By conducting the stereomicroscopic analysis, it was determined that the residence permit specimens are individualized by laser engraving. Counterfeit residence permit made of PET are individualized by inkjet printing, while individualization by laser engraving (3) or thermal printing (10) is present only on counterfeits made of PMMA.

Video-spectral analysis revealed that on the counterfeits made of PMMA imitated security features are of a good quality (Figure 4).

By conducting the stereomicroscopic analysis, it was determined that the residence permit specimens are individualized by laser engraving. Counterfeit residence permit made of PET are individualized by inkjet printing, while individualization by laser engraving

3.1.4. Identification of polymer of genuine and counterfeit polymers documents

The identification of the polymer samples analysed by the FTIR-ATR method was carried out by comparing the IR spectra of the analysed samples with IR spectra from available databases. It was determined that the specimens are made entirely of polycarbonate (PC), while counterfeit documents are made from three types of polymers: Polymethylmethacrylate (PMMA), Polyethyleneterephthalate (PET) and Polyvinylchloride (PVC). The obtained FTIR spectra of polymers are shown in Figure 6.

In general, the identification of polymers analysed by the FTIR-ATR method can be carried out by comparing the IR spectra of the analysed polymers with IR spectra from available databases, but also by determining

the position of the bands in the IR spectra of the analysed ones [10-18].residence permit specimens were made of polycarbonate (PC), while thirteen (13) counterfeit residence permits were made of PMMA, and one (1) counterfeit residence permit was made of PET.

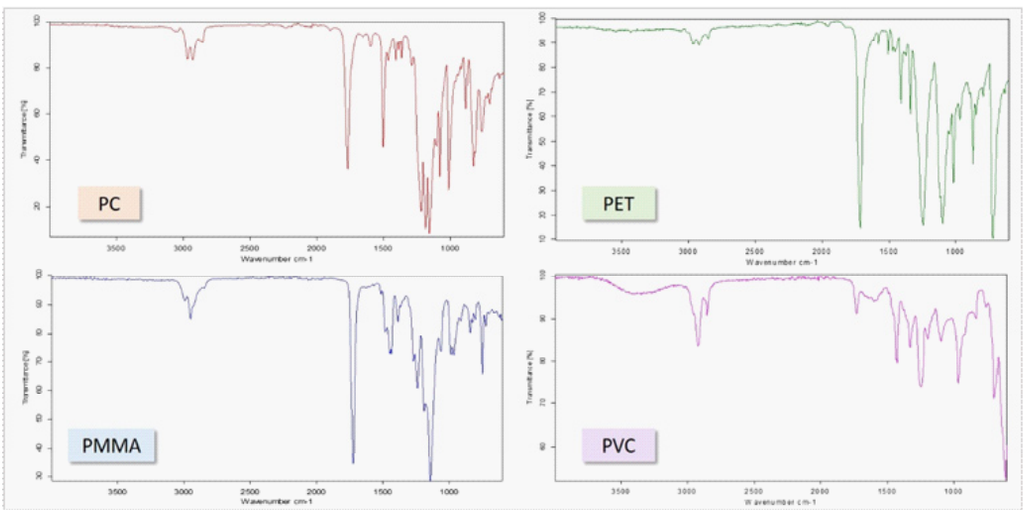

Figure 6. IR-spectra of different types of polymers (PC, PMMA, PET, PVC).

An analysis of collected FTIR spectra of specimens of polymer identity cards, driving licenses and residence permits, issued by thirteen (13) EU Member States was carried out and it was determined that they are made entirely of polycarbonate (PC) [10, 11].

This is in line with the provisions of the EU Regulations, which stipulate that security documents issued by EU MS in ID-1 (card) format shell be made of polycarbonate (PC) or equivalent synthetic polymer. The EU Member States have chosen polycarbonate (PC) as the prime substrate for the production of security documents, which was confirmed by the conducted analysis of the specimens, as is presented in this paper. Analysis of the FTIR spectra of the polymers of counterfeit documents revealed that they are made of PMMA [12, 13, 14], PET [15, 16] or PVC [17, 18]. Analysis of collected FTIR spectra of eighty-two (82) counterfeit polymer documents originating from thirteen (13) EU countries revealed that fifty-eight (58) of them were made of PMMA, nineteen (19) of PET and five (5) of PVC. Individualization by laser engraving is present only on counterfeits made of PMMA, which is related to the physicochemical properties of that polymer [19]. Namely, PMMA is a polymer that has a high resistance to exposure to sunlight, good thermal stability, very good mechanical properties, and is also one of the hardest thermoplastics with high resistance to scratches. Therefore, it is a suitable material for the production of counterfeit documents because the image and data of the document holder can be laser engraved without destroying the polymer [19]. Counterfeit polymer documents made of PET are individualized using an inkjet printer or by thermal printing. Those made of PVC are individualized by inkjet printing. According to the available literature, PET is a more thermostable polymer than PVC, so, this is the probable reason for the personalization by thermal printing [20].

Among the analysed samples of counterfeit polymer documents there were no documents made of PET or PVC in which individualization is done by laser engraving. All three types of polymers used for the production of

counterfeit documents (PMMA, PET, PVC) are commercially available and the probable reason for using PMMA for the production of counterfeits which are individualized by laser engraving is its better physicochemical properties than PVC and PET [19, 20, 21].

4. Conclusion

Counterfeit identity cards, driving licenses and residence permits made of PMMA, PET or PVC, are individualized using different techniques, which depend on the type of polymer. Counterfeit documents that are individualized by laser engraving have well-imitated security features, therefore additional caution and special care is required when examining these documents - it is necessary to carry out a detailed analysis of the numerous security features that are part of modern travel and identification documents and to keep in mind the fact that individualization by laser engraving does not mean that the document is legally issued.

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