



DETERMINATION OF BLOOD SPECIES BASED ON IMMUNOLOGICAL REACTIONS

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Abstract

This article provides a comprehensive overview of the formation and development stages of methods for determining the species-specific characteristics of blood proteins, their theoretical foundations, and practical significance in forensic medical examination. A comparative analysis of the specific features of immunological and non-immunological methods is conducted, and in particular, the diagnostic capabilities, sensitivity, and specificity of the precipitation reaction, immunodiffusion in agar gel, and radial immunodiffusion methods are assessed. Furthermore, the application of modern optical and laser technologies, their advantages, and prospects for practical implementation are analyzed. The research results indicate the need to improve methods for identifying blood traces in forensic practice.

Keywords: blood proteins, species specificity, antigen-antibody reaction, precipitation, immunodiffusion, radial immunodiffusion, forensic medical examination, diagnostics.

The problem of determining the species of blood holds an important place in forensic medicine and biology. This issue not only sparks scientific interest but also has great practical significance in solving crimes, identifying biological evidence, and identifying individuals. Historically, the earliest methods for species determination of blood were based on simple observation and empirical approaches. In particular, methods such as determining the smell of blood, studying the morphological structure of dried bloodstains, and comparing the size of erythrocytes were employed. Subsequently, methods based on the shape and physicochemical properties of hemoglobin crystals were developed. However, these methods are characterized by low levels of accuracy and reliability. For this reason, scientifically-based immunological methods with high sensitivity and specificity are of paramount importance in determining the species of blood today.

In modern forensic practice, methods for determining the species of blood are divided into two main groups:

- immunological methods
- non-immunological methods

Immunological methods are based on the interaction between antigens and antibodies and are distinguished by a high degree of accuracy and specificity. Non-immunological methods, conversely, are based on analyzing the physicochemical properties of blood, and their diagnostic capabilities are relatively limited. Immunological Methods and the Precipitation Reaction Among immunological methods, the precipitation reaction holds a special place. This method is based on the formation of insoluble complexes between antigens and antibodies and is widely used in forensic practice.

Its main advantages include:

- relative simplicity of execution;
- providing a rapid result;
- convenience for practical application.

At the same time, the following shortcomings also exist:

- insufficiently high sensitivity;
- the occurrence of non-specific reactions;



- complexities in examining small volumes of biological material.

The Problem of Non-Specific Reactions

One of the significant disadvantages of the precipitation reaction is the formation of non-specific precipitates. This situation negatively affects the reliability of the analysis results.

Non-specific reactions are associated with the following factors:

- the effect of chemical substances (acids, alkalis, salts);
- environmental factors (wood, fabric, and other carrier surfaces);
- washing agents and detergents;
- contamination or degradation of the biological material.

Therefore, it is important to create standardized conditions in forensic medical research and to minimize the influence of external factors.

Immunodiffusion Methods in Agar Gel

To improve the precipitation reaction, immunodiffusion methods in an agar gel medium have been developed. These methods are based on the diffusion of antigens and antibodies within the gel.

Main types:

- double diffusion (Ouchterlony method)
- simple diffusion
- linear immunodiffusion

Advantages of these methods:

- high specificity;
- the ability to examine contaminated and turbid samples;
- ease of visual assessment of the results.

Disadvantages:

- low sensitivity;
- requiring more time for analysis;
- the possibility of incorrect interpretation in some cases.

Scientific and Practical Significance of the Radial Immunodiffusion Method

The radial immunodiffusion method is one of the modern immunological analysis techniques, distinguished by high sensitivity and accuracy.

In this method, antigens diffuse radially within the agar gel and react with antibodies, forming ring-shaped precipitation zones. The diameter of these zones is proportional to the quantity of the antigen.

Advantages:

- high sensitivity and accuracy;
- a high degree of specificity;
- the ability to analyze a small quantity of sample;
- the possibility of conducting quantitative analysis.

Although this method is widely used in immunology and laboratory diagnostics, it has not yet been sufficiently implemented in forensic examinations.

Modern Technologies and Innovative Approaches

In recent years, high-tech methods for detecting immunological reactions have been proposed.

These include:

- optical shift spectroscopy
- laser-based indicator systems

The advantages of these methods are:



- very high sensitivity;
- the ability to detect micro-quantities of biological material;
- registration of reactions invisible to the naked eye.

For example, using optical methods, blood can be detected even when it is in a highly diluted state.

However, the following factors hinder the widespread practical implementation of these methods:

- the need for complex technical equipment;
- high economic costs;
- the complexity of the methodology.

Conclusion: Methods for determining the species-specific properties of blood proteins have improved significantly in the course of scientific progress. Currently, the precipitation reaction is used as the main method in forensic practice. However, its low sensitivity and the presence of non-specific reactions necessitate the development of new, highly effective methods. Agar gel immunodiffusion and especially radial immunodiffusion methods possess high specificity and sensitivity and are regarded as a promising direction. Furthermore, the introduction of optical and laser technologies will serve to increase the accuracy and reliability of forensic examinations. In the future, scientific research in this area is expected to elevate forensic practice to a new level.

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