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Shapiro A L, Viñuela E & Maizel J V. Molecular weight estimation of polypeptide chains by electrophoresis in SDS-polyacrylamide gels. *Biochem. Biophys. Res. Commun.* 28:815-20, 1967.
[Dept. Ophthalmology and Dept. Biochemistry, New York Univ. Sch. Medicine, and Dept. Cell Biology, Albert Einstein Coll. Medicine, Bronx, NY]

This article described a simple method to estimate the molecular weight of proteins. The method was based on the finding that the logarithm of the molecular weight was inversely proportional to the electrophoretic mobility of the proteins complexed with the detergent sodium dodecyl sulfate. [The *SCI*® indicates that this paper has been cited in more than 3,475 publications, making it the most-cited paper from this journal.]

From Golf Courses to Protein Labs

Eladio Viñuela
Centro de Biología Molecular
CSIC-UAM
Cantoblanco 280 49 Madrid
Spain*

After my PhD work with Alberto Sols on carbohydrate metabolism, completed in 1964, I went to Severo Ochoa's laboratory at the Department of Biochemistry at New York University, where I joined Charles Weissmann in a study of RNA replication of bacteriophage MS2. About a year later, I proposed to Ochoa a project of my own for the characterization of the proteins induced in *Escherichia coli* infected by the phage MS2. During the course of this research, I came across the idea of electrophoretic estimation of the molecular weights of proteins.

Israel Algranati, a postdoctoral student from Luis Leloir's lab, and I joined efforts to carry out the project and were soon frustrated by difficulties in dissociating the virion proteins before electrophoresis. A paper by Jacob V. Maizel, Jr.,[1] showing the separation of adenovirus proteins by gel electrophoresis in the presence of sodium dodecyl sulfate (SDS) rescued us from the impass, and we reported our progress in a paper by Ochoa, Algranati, and myself.[2] The effectiveness of SDS over other detergents as an agent for dissociating viruses had been demonstrated almost 30 years earlier by Norman W. Pirie, who was encouraged to use detergents for that purpose by Sydney Cole of Cambridge University, England. As told by Pirie,[3] Cole was an ardent golfer who took an interest in green-keeping, and the detergents first used were those that had been sent to him to test as spreading agents for substances used to kill weeds and worms.

Algranati left for Buenos Aires in 1966, and I continued working on phage MS2 mutants. I shared the lab with Wendell Stanley, Jr., who one day came back from a Cold Spring Harbor meeting with the news that proteins moved according to their size in sucrose gradient centrifugation in the presence of SDS. I immediately reacted to this news by raiding the refrigerators of the department for homogeneous proteins of known molecular weight and started running polyacrylamide gels in the presence of SDS. The system worked! The logarithm of the molecular weight of the proteins was inversely proportional to their electrophoretic mobility. As I was about to return to Madrid, where I had to start a new laboratory, I decided to ask Arnold L. Shapiro, a former collaborator of Maizel, who was working at the time on the same floor at the Department of Ophthalmology, whether he would be willing to add some additional experiments and write a draft of the paper. A month later, I received a manuscript under the authorship of Shapiro, Viñuela, and Maizel.

The discovery reported in the paper made the estimation of the molecular weight of proteins an extensively used method that, to a large extent, liberated biochemists from the expensive and more cumbersome methods based on analytical ultracentrifugation. The finding by J.A. Reynolds and C. Tanford,[4] that most of the proteins bind the same amount of SDS per mass unit, explained the empirical relation of molecular weight and electrophoretic mobility. Technical refinements introduced by various authors, especially those of K. Weber and M. Osborn[5] and U.K. Laemmli,[6] have contributed to the present-day popularity of the method.[7]

1. **Maizel J V.** Acrylamide gel electrophoresis by mechanical fractionation: radioactive adenovirus proteins. *Science* 151:988-90, 1966. (Cited 595 times.)
2. **Viñuela E, Algranati I & Ochoa S.** Synthesis of virus-specific proteins in *Escherichia coli* infected with the RNA bacteriophage MS2. *Eur. J. Biochem.* 1:3-11, 1967. (Cited 190 times.)
3. **Pirie N W.** Retrospect on the biochemistry of plant viruses. (Goodwin T W, ed.) *British biochemistry: past and present.* London: Academic Press, 1970 p. 43-56.
4. **Reynolds J A & Tanford C.** The gross conformation of protein-sodium dodecyl sulfate complexes. *J. Biol. Chem.* 245:5161-5, 1970. (Cited 615 times.)
5. **Weber K & Osborn M.** The reliability of molecular weight determinations by dodecyl sulfate-polyacrylamide gel electrophoresis. *J. Biol. Chem.* 244:4406-12, 1969. (Cited 21,085 times.)
6. **Laemmli U K.** Cleavage of structural proteins during the assembly of the head of bacteriophage T4. *Nature* 227:680-5, 1970. (Cited 73,270 times.)
7. **Garfin D E.** One-dimensional gel electrophoresis. *Meth. Enzymology* 182:425-41, 1990.

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