Table 1: Summarization of works reported on liver diseases biomarkers using flow-based analysis systems. FI: flow injection; FI-BI: flow injection-bead injection; SI: sequential injection; LOC: lab on chip.

Flow-based system	Detector	Reagent (s)	Biomarker sample	Detection Limit	Working range	Sample throughput	% RSD	Reference no.
FI	Florescence spectrometer	Fluorescein, sodium hypochlorite and surfactant	Albumin in urine	0.03 μg/mL	0.05–24 μg/mL	—	0.8	[28]
FI	Rayleigh light scattering	Amide Black -10B	Albumin in serum	0.11 μg/mL	—	—	<3	[33]
		Dye acid chrome blue K	Total protein in serum	85 ng/mL	2–40 μg/mL	60/h	<2	[34]
		Eriochrome black T		0.8 μg/mL	7–36 μg/mL	90/h	0.76	[35]
FI	Visible spectrometer	Tetrabromophenolphthalein Et ester triton x-100 (micelle formation reagent)	Albumin in urine	0.05 mg/dL	0.15–12 mg/dL	30/h	1.2	[31]
		Sulfate sulfatase enzyme immobilized on beads packed in reactor	Sulfate bile acid	—	1–75 μM	15/h	<1	[40]
FI	Surface Plasmon resonance spectrometer	Gold surface	Albumin in serum	500 μg/dL	—	90 s/sample	—	[46]
FI	Biolumines-cence spectrometer	coimmobilized luciferase and NADH:FMN oxidoreductase on hollow fiber reactor	3-alpha hydroxyl bile acid in serum	—	1–7.5 μM	>20/h	6–8	[41]
FI-BI	Visible spectrometer	Wheat germ lectin-coated beads and para-nitro phenyl phosphate (PNPP)	Alkaline phosphatase in serum	10 U/L	10–1000 U/L	30 min/sample	5-6	[32]
SI	Visible spectrometer	Hyaluronan standard coated glass capillary, biotinylated HA binding proteins, anti-biotin-HRP and Tetra-methyl benzidine substrate for immunoassay	Albumin in serum	9 ng/mL	Linear 25–500 ng/mL	20 min/sample	3–5.5	[26]
Nanofluidic (LOC)	Fluorescence spectrometer	Fluorescein label	Albumin in serum	0.3 pM	0.3–3 pM	200 s/sample	—	[30]
Microfluidic	Amperometer Glass chip	Substrate conjugated albumin packed in microflow channel	Activity of enzymes (glutamic oxaloacetictransaminase, glutamic pyruvic transaminase, γ-glutamyl transpeptidase)	—	Up to 100 −300 U/L	—	—	[36]

of reactor [41] is a commercial hollow fiber reactor with cuprammonium rayon membrane for immobilization of enzyme. These works sought detection of bile acids in urine and serum, respectively. Flow injection facilitated the introduction of sample solution and reagent into the reactor and simultaneously transported the colored/luminescent product to the detector.

Many biomarkers are protein or enzyme which normally can be determined using immunoassay technique. Conventional immunoassay technique is carried out in microplate format where multisteps incubations and washing are done in an array of small plastic wells, each accommodating 100–500 μL volume of solution. The test requires skillful lab personnel to obtain precise and accurate results from